electronics

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The march of the electronic arts

Film producers to spend millions in 1931

What is expected to be one of the greatest booms in picture production since the advent of sound pictures is forecast for 1931, by leading executives of the industry. Adolph Zukor, of Paramount Publix Corporation has announced that his studios would produce approximately 55 or 60 feature pictures in Hollywood and 5 to 20 features in the company's New York Studios under a budget estimated at $25,000,000.

Metro-Goldwyn-Mayer Studios are laying plans for approximately 50 feature pictures and also additional foreign language pictures.

Warner Brothers, including First National, has announced plans for over 70 feature pictures making the largest production program undertaken by the company.

United Artists and Universal Pictures are planning the production of 20 features each necessitating a budget of $15,000,000. Fox Film Corporation has a program calling for upwards of 50 features. Radio Pictures has planned on 30 or more features, while Pathe, Columbia and others are also planning large schedules.

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State radio quotas concern Commission

Anticipating an outcry in Congress against the present division of radio broadcasting facilities among the states, all of the members of the Federal Radio Commission with the exception of Commissioner H. A. Lafount have advanced plans for meeting the state quota obligations imposed by the Davis equalization amendment.

The Davis amendment prescribes an equal division of wavelengths, power and hours of operation among the five zones into which the country is divided for radio administrative purposes and then a division among the states within those zones in proportion to their populations.

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BEAM MICROPHONE

Developed by RKO Studios, Hollywood, this parabolic reflector with microphone placed at the focus is used for long distance pick-up in recording sound pictures

U. S. Supreme Court holds film producers in trust

Ten of the largest motion picture producers in the country and 32 film-distributing boards handling 98 per cent of motion picture film output in this country, were held guilty of violating the Sherman anti-trust law in two decisions handed down November 24, by the United States Supreme Court.

The producers and distributors involved in the two cases before the Court included: Metro-Goldwyn-Mayer Distributing Corp.; Paramount-Famous-Lasky Corp.; Universal Film Exchanges, Inc.; United Artists' Corp.; F-O-B Pictures Corp.; Fox Film Corp.; Pathe Exchange, Inc.; Vitagraph, Inc.; Educational Film Exchanges, Inc., and First National Pictures, Inc.

Justice McReynolds, in referring to the standard exhibitors contract, stated: "Certainly it is unusual, and we think—directly tends to destroy the kind of competition to which the public has long looked for protection. Ten producers and distributors of films controlling 60 per cent of the business agreed to contract with exhibitors only according to a standard form and then combined through thirty-two local film boards of trade with other distributors, who with themselves control 98 per cent of the entire business.

"In order to establish violation of the Sherman Act it is not necessary to show that the challenged arrangement suppresses all competition between the parties or that the parties themselves are discontented with the arrangement. The interest of the public in the preservation of competition is the primary consideration. The prohibitions of the statute cannot be evaded by good motives."

Paramount startles industry with new 65 mm. equipment

Dr. N. M. LaPorte of the Paramount Publix Corporation, unveiled for the first time, to the New York Chapter of the Society of Motion Picture Engineers, on December 5, the new 65-mm. camera and projection equipment about which there has been so much secrecy for months. All of the equipment shown was developed and manufactured abroad. The projector is an Ernemann unit built in Germany and is of most unusual design. The projection head is a multiple type accommodating either 35 mm. or 65 mm. film. The aperture opening used for the wide-film shown is 23 x 41 mm. making a picture ratio of 1 to 1.78. The lenses for the projector and camera were designed by Carl Zeiss, Jena.

The new wide-film camera, which was built by DeBrie Etablissement, Paris, is also of unique design. It is built on a pedestal provided with an electric motor for propulsion; the camera unit can be steered about the set with a control lever similar to handling a motor car. The camera may be raised or lowered by motor power on the pedestal shaft. The camera is provided with a 230 degree shutter opening. Several reels made with this new wide film equipment were shown.

A new form of optical printer also built by DeBrie for Paramount and used in making reduction prints from 65 mm. to any width was exhibited.

Films showing Paramount's new color system were presented. These films were made by a three-color additive process and the definition and lighting values were most excellent indicating great progress in color photography.

Dr. LaPorte pointed out that all the film equipment shown was adaptable to any standard width that might be agreed upon by the industry.

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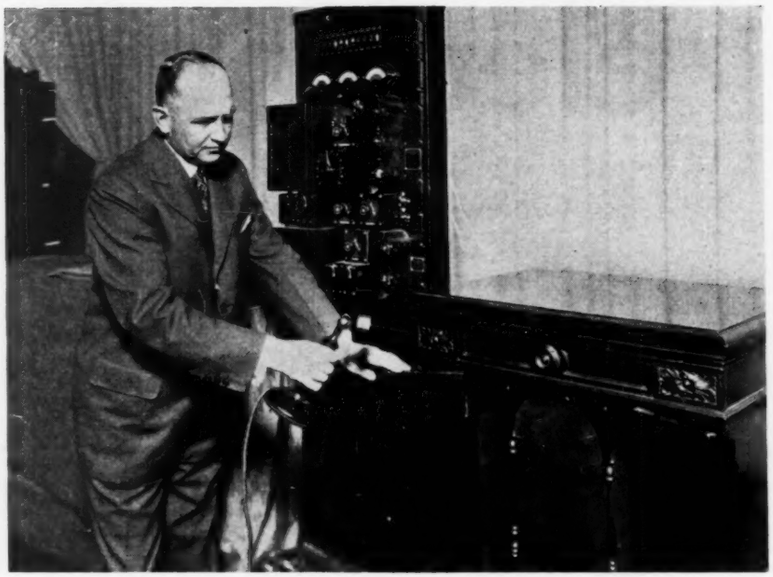
EAVESDROPPING OF NO VALUE HERE



Sergius P. Grace of the Bell Laboratories is shown demonstrating apparatus used for scrambling speech, making possible secret transatlantic radio telephone conversations

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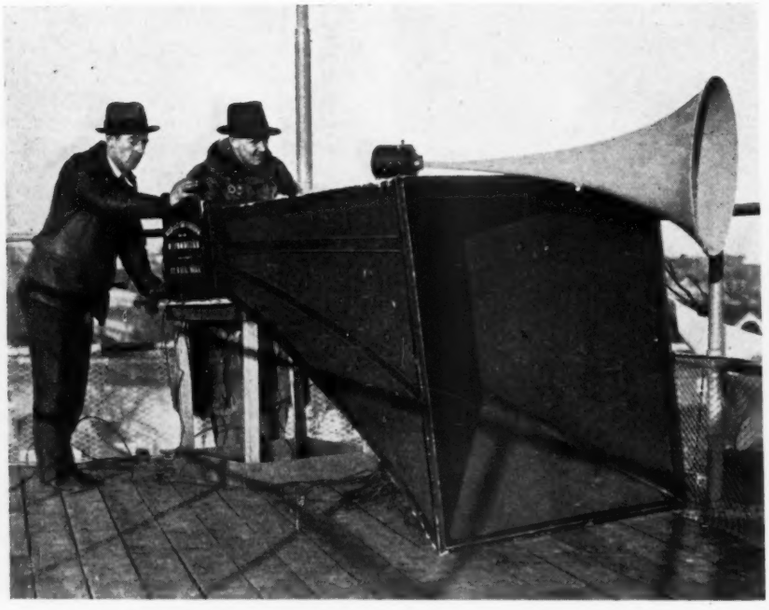
TO CHEER HARVARD'S CRIMSON TEAM



This loud-speaker unit, said to be one of the largest in use, has been installed at the football stadium at Harvard, Cambridge, Mass. Announcements made from it can be heard with clarity over the entire field

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Amplifier business growing

A lusty growing infant of the radio family is the amplifier manufacturing branch. Amplifiers in theaters, auditoriums, public parks, ball rooms, railway stations and similar places are becoming so widely used that the manufacturing of amplifiers is one of the rapidly growing developments in radio. To meet the needs of amplifier manufacturers the Radio Manufacturers Association has approved new services to be afforded to the amplifier group, headed by A. C. Kleckner of the Webster Electric Company, Racine, Wisconsin, chairman. There has also been approved a recommendation of Chairman Kleckner to form a special amplifier section of the Standards Committee of the RMA Engineering Division. The amplifier section will develop standardized ratings for power amplifiers and also cooperate with the National Board of Fire Underwriters in drawing up a satisfactory set of standards covering amplifiers. Export trade in amplifiers and traffic, statistics, legislative and other interests of amplifier manufacturers also will be specially developed by respective RMA committees.

"Business" will be keynote of 1931 RMA trade show

The annual convention and trade show of the Radio Manufacturers Association in 1931 will be held in some middle western city and during the first or second week in June, under a decision reached November 18, at a meeting of the RMA board of directors at the Hotel Cleveland. Business, without ballyhoo, will be the keynote of the 1931 gathering of the radio industry, which is the largest industry assemblage in the United States and which drew over 32,000 persons to Atlantic City.

Choice of a meeting place for the 1931 meeting was deferred temporarily by the RMA directors. There is keen competition for the 1931 trade show between the cities of St. Louis, Pittsburgh, Chicago and Detroit, and one of these four cities soon will be definitely selected. The RMA Board plans to hold the 1931 convention and trade show under one roof and along simplified, economical lines, with the least possible expense to exhibitors and trade visitors. There will be reduced railroad rates to the convention city and no increases in normal hotel rates.

To insure exhibition of new and current radio merchandise in the 1931 show, the RMA board of directors adopted a new rule which will require all exhibitors to show their new or current receiving sets and other radio lines. This rule will prevent recurrence of exhibit conditions in the last show.

Another new rule for the trade show will permit exhibition, not in the show but in the demonstration rooms of exhibitors, of associated radio products made by manufacturers in addition to receiving sets, etc.

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Gifford predicts early prosperity

Walter F. Gifford, President of the American Telephone and Telegraph Co., speaking to members of the Essex Institute in Salem, Mass., on November 24, said: "As sure as I am standing here, this depression will soon pass, and we are about to enter a period of prosperity, the like of which no country has ever seen before; a new era of big business working for the fulfillment of its social obligations; and a new development in industry to work out the problems of distributing what we have on the basis that we have a plenty to go around."

Mr. Gifford stated it was inevitable that business through science would work toward an industrial and social Utopia, which would be gained by the perfection of the best and cheapest possible service consistent with financial safety.

LABORATORY ON WHEELS

This motor truck is equipped with complete acoustical measuring equipment for making analysis of theaters and auditoriums. Designed by Warner Bros. Studio, Brooklyn, N. Y.

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Radio interference

A plan for cooperation between radio manufacturers to reduce the interference troubles of the radio public has been adopted by the Radio Manufacturers Association. The association's board of directors, meeting November 18, at Cleveland, approved the program presented by H. B. Richmond of the General Radio Company, Cambridge, Mass., chairman of the RMA engineering division, to enlist the cooperation of manufacturers on interference work. This will be carried on through a special interference section of the engineering division and later it is planned to enlarge the interference service for the owners of radio receiving sets by the establishment of a separate bureau in the RMA for such interference work, under the direction of competent engineers.

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Short-wave channels made available to film industry

The Federal Radio Commission, on November 26, set aside three continental short-wave channels for the use of motion picture producers. Frequencies of 1552 and 1556 kilocycles, hitherto reserved for ship stations, have been made available for temporary use in connection with the production of motion pictures. Power on these frequencies is limited to 250 watts. A third channel, on 1554 kilocycles, was set aside for radio-telephone contact.

The purpose of these channels is to provide facilities for communication between parties "on location" with the main studios. This will provide the necessary means of communication to location parties in desert areas, shipboard, etc., where no other means of communication are available. Such facilities will speed up production of talkies and shorten the period of maintaining parties on location.

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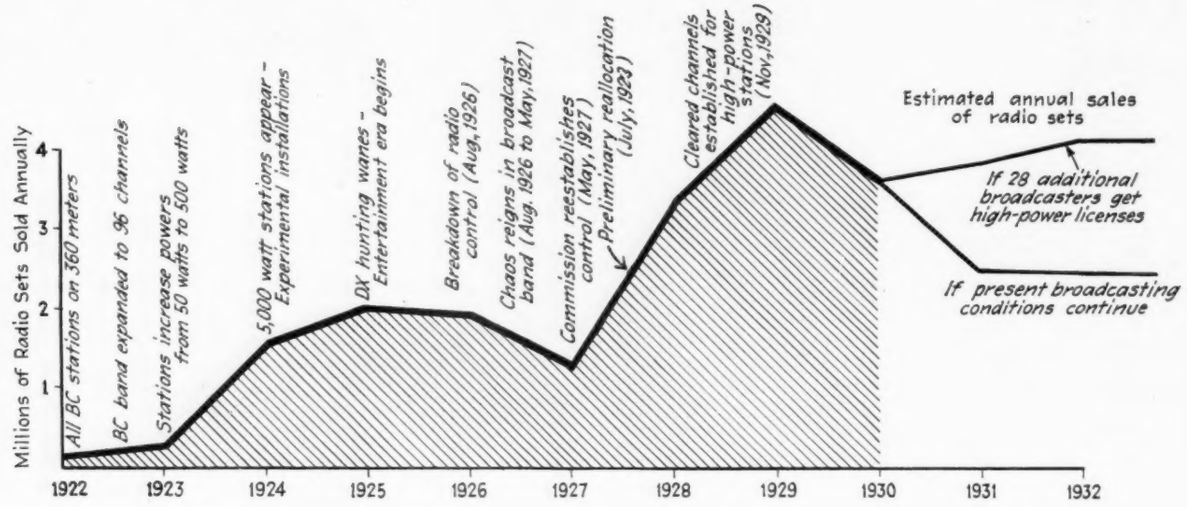
CROOKS AND GANGSTERS BEWARE

View of teletype machine over which alarms are sent simultaneously to all precincts by the police department of Dearborn, Michigan. This equipment, with radio on police cars, will not make the criminal's lot any easier

Broadcast-station POWER



Annual sales of radio-receiving sets, 1922 to 1930, showing influence of broadcasting conditions on public's purchases

By O. H. CALDWELL

Editor Electronics, Former Federal Radio Commissioner

IN FEW other places in industry or business is there such a close relationship as exists between the quality of broadcasting service supplied to the public, and the public's response in the form of the purchase of radio sets. Radio-receiver sales in any territory depend upon the technical and program character of the broadcast service received, as can be shown by repeated examples when tracing the history of broadcasting to date.

In 1926, when the radio law broke down and radio broadcasting relapsed into a state of chaos, the effect was immediately shown in the collapse of retail radio sales. Again, as early powers of broadcasting stations were increased, radio sales mounted upwards.

Better broadcasting is thus an effective stimulant to radio-set sales. One cannot sell radios unless there is broadcasting; just as one cannot grow a garden unless there is sunshine. Obvious as this relationship would seem to be, there has yet been a surprising lack of attention given to the broadcasting situation by those whose business investments most depend upon it. Executives of radio manufacturing companies too often have felt or shown little interest in this vital service, which is the very life blood of their continued radio business activity.

Within the last two weeks, representatives of *Electronics* have interviewed radio leaders who have responsibility for producing and selling a large part of the country's radio sets.

These men all seem to expect a contraction in radio sales volume during 1931 and 1932. They say that "saturation" is now so far advanced that we cannot again have a 4-million-set year.

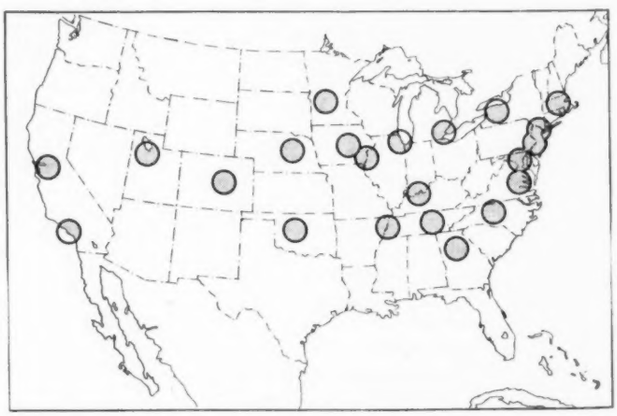
But is this the inexorable picture facing us?

Let us look at the real facts of the situation from the broader angles of the radio art.

In those parts of the United States where good broadcasting service (that is, high signal strength) is now being had, it is true that saturation of receiving sets is now approaching a fair degree of intensity,—for all of the radio sets sold during recent years have been going into these regions.

But there are still vast populated regions of the country where broadcasting is pitifully poor,—where the extent of the broadcasting receivable is a *single faint program,* available only *during night hours* in *winter*

We must open up new territories for receiver selling, if 1931 and 1932 volumes are to repeat past levels. Higher powers for existing stations will do it.



Present "fair-quality" service areas of the 28 broadcasting stations (chiefly 5 kw.) which are now asking the Radio Commission for 50 kw. licenses

and 1931 radio-set SALES

time. Such broadcasting service of course cannot produce radio sales.

Forty per cent of the nation's population live seventy-five miles or more from broadcasting stations furnishing consistent regular satisfactory programs. In these poorly served territories, where only one or two programs are received, each spoiled by static, few radio-sets, naturally, are yet in use. But these populated areas offer great opportunities for future radio-set sales, as has been demonstrated each time an increase in power has been granted to the broadcaster serving such a territory.

The solution of the radio industry's problem, therefore, is to get existing broadcasting stations to increase their powers to reach these now sterile sections. At this moment, 28 leading independent broadcasters from all parts of the country are in Washington applying to increase their powers to 50 kw., being willing to spend $300,000 each to improve their service ranges—the very thing that all the listeners, the farmers, and the radio manufacturers and dealers most want them to do.

Only the Radio Commission, operating against the consensus of all engineering opinion, holds back against this necessary and inevitable action,—on account of political pressure from its Senate masters (who do not yet comprehend high power as an improved service to the rural and farm population).

Independent broadcasters in majority

Already many radio manufacturers and other industry leaders are on record as favoring high-power. For their own self-preservation, however, the present emergency demands that they go emphatically further, entering the battle vigorously in the interest of the whole radio industry. This matter of high power is not a question involving the so-called "radio trust" stations. The 28 broadcasters applying are chiefly *independent,* far-seeing public-spirited concerns,—newspapers, educational institutions, department stores, business houses, etc., from all parts of the country, independent of any radio-trust ownership or control whatever.

HIGHER POWERS FOR STATIONS ON CLEARED CHANNELS WILL—

Bring clear, strong signals to millions now poorly served

Open up vast new territories for receiver sales

Improve summer reception everywhere, ironing out summer slump and extending production-period of radio factories

Usher in $100,000,000 of waiting receiver sales

Open up $10,000,000 business in broadcasting apparatus

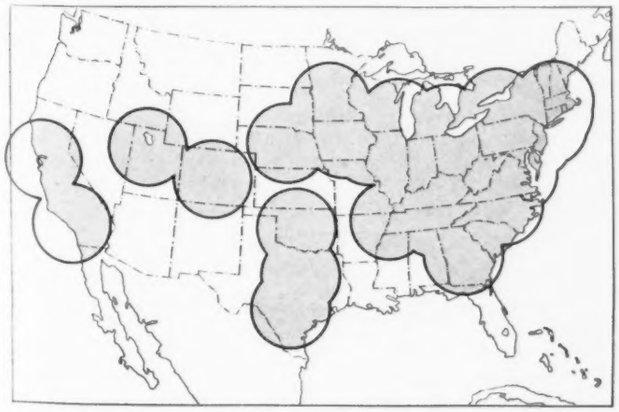
Restore employment to 100,000 radio workers

The moral influence of the radio industry and trade, exerted through its representatives in Congress will speed Commission action on high power immeasurably by interpreting the situation to the Senators in its true terms of high power as a service to the rural population.

The direct effect would be to put good clear strong broadcasting into all the now unsaturated territories, and so immediately to stimulate sales of receiving, as has been repeatedly demonstrated locally where broadcast stations have increased their powers.

With radio manufacturing volume next year otherwise facing saturation, prompt action in getting high-power broadcasting is the one remaining fundamental factor which can restore radio sales to their past happy situation of 3 and 4-million-set years.

Thus upon the prompt action of the Radio Commission in granting high-power licenses, there now await $10,000,000 in broadcast station sales; $100,000,000 in receiving set sales; the future prosperity of the radio industry, and the employment of a hundred thousand radio workers.



"Fair-quality" service areas of the 50-kw. broadcast stations of U. S. as they would appear if applications now before Commission were granted

Broadcasting stations applying for 50 kw.

WHAM	Rochester, N. Y.	Stromberg Carlson Telephone Mfg. Co.
WOR	Newark, N. J.	Bamberger's Department Store
WBZ	Springfield, Mass.	Westinghouse Elec. & Mfg. Co.
WBAL	Baltimore, Md.	Consolidated Gas & Elec. Co.
WHAS	Louisville, Ky.	Courier Journal
WCAU	Philadelphia, Pa.	Universal Broadcasting Co.
WWJ	Detroit, Mich.	Detroit Evening News
WRVA	Richmond, Va.	Larus Bros. & Co.
WJR	Detroit, Mich.	The Goodwill Station, Inc.
WBT	Charlotte, N. C.	Queen City Broadcasting Co.
WSM	Nashville, Tenn.	National Life Insurance Co.
WSB	Atlanta, Ga.	Atlanta Journal
KVOO	Tulsa, Okla.	Southwestern Sales Corp.
WREC	Nashville, Tenn.	WREC, Inc.
WMC	Memphis, Tenn.	Commercial Appeal
KFAB	Lincoln, Nebr.	Buick Auto Company
WCCO	Minneapolis, Minn.	Washburn-Crosby Mills
WTMJ	Milwaukee, Wis.	Milwaukee Journal
WCN	Chicago, Ill.	Chicago Tribune
WMAQ	Chicago, Ill.	Chicago Daily News
WCFL	Chicago, Ill.	American Federation of Labor
WBBM	Chicago, Ill.	Atlass Brothers
WHO	Des Moines, Iowa	Bankers Life Ins. Co.
WOC	Davenport, Iowa	Palmer School of Chiropractic
KGO	San Francisco, Cal.	General Electric Company
KOA	Denver, Colo.	General Electric Company
KSL	Salt Lake City, Utah	Mormon Church
KPO	San Francisco, Calif.	San Francisco Chronicle
KHJ	Los Angeles, Calif.	Don Lee, Automobiles

Analysis of uniform r.f. amplification

By EDWIN A. UEHLING

AMONG the principal aims of all research in the field of radio-frequency is the development of an amplifier capable of high sensitivity and selectivity; and capable, moreover, of maintaining these characteristics with a high degree of uniformity over the entire broadcast range. Inasmuch as this is a range of three to one in frequency, and of nine to one in the variable parameter of the amplifier, this aim toward which development has proceeded will constitute no mean accomplishment when achieved. Progress has been so persistent during the years of the history of radio engineering that one might say the goal in question has been very nearly reached.

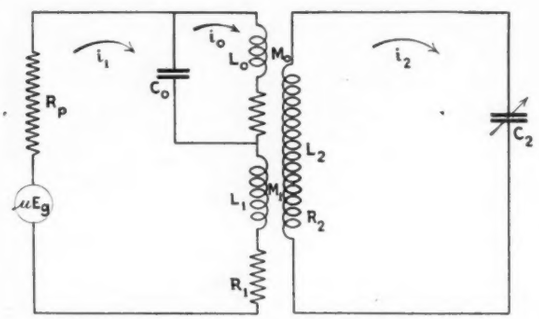


Fig. 1—Circuit suggested for effecting uniformity of amplification

Uniformity of selectivity and uniformity of sensitivity are separate problems and are usually treated as such, though, of course, they are related in many particulars, and a complete treatment of one cannot be carried out without due consideration of the other. Nevertheless, it is our purpose at this time to consider exclusively the problem of uniform amplification. The methods to be described have been used frequently, and may find a more or less universal application in the future. However, an adequate description of the theory of uniform amplification is lacking, and in view of the importance of the subject, such a description may be of considerable value to many engaged in certain fields of research.

Non-uniformity is inherent

We will ascertain the nature of non-uniformity of amplification before discussing the means of controlling it. The current in the tuned circuit of a transformer coupled stage of radio-frequency amplification is given by the equation

$$I_2 = \frac{\mu E_g \omega M}{\omega^4 M^2 + R_p R_2}$$

where μ is the amplification factor of the tube, E_g is the impressed signal voltage on the grid of the preceding tube, ωM is the mutual impedance, R_p is the plate circuit resistance of the tube, and R_2 is the tuned circuit resistance. As the frequency is varied all factors in this equation except ω and R_2 are constant. Rewriting the equation to give the amplification directly, we have

$$\text{Amplification} = \frac{\mu M L \omega^2}{\omega^2 M^2 + R_p R_2}.$$

The extent to which the amplification will vary with change in frequency will depend on the value of the term R_pR_2 as compared with ω^2M^2, and on the amount of variation in R_2 with frequency. But in order to realize the maximum possible amplification at any given frequency ω^2M^2 should be equal to R_pR_2 at this frequency. In general this condition is difficult to realize because of practical considerations. One permits himself to feel fortunate if he can make the term ω^2M^2 equal to or nearly equal to the term R_pR_2 at the highest frequency of the broadcast range. Having established this condition he has given to the amplifier the highest possible amplification at all frequencies attainable under the circumstances for which the amplifier is designed. The characteristic, however, will be anything but independent of the frequency. If optimum conditions can be established at only one frequency, the amplification frequency curve must necessarily reflect this condition.

A first derivative of the equation with respect to ω may be taken, considering R_2 in this equation as one of the variables. If R_2 is considered to vary directly as the frequency, the derivative of the equation will be of the form

$$\frac{K'}{(\omega M^2 + K'')^2}$$

where K' and K'' are positive constants. The first derivative is therefore positive for all frequencies regardless of the relative values of ω^2M^2 and R_pR_2 at any particular frequency. Consequently the amplification increases with increasing frequency for all conditions of coupling: deficient, critical, and sufficient coupling. While an increase in ωM produced by an increase in M causes an increase in amplification until $\omega^2M^2 = R_pR_2$, beyond which no further increase in amplification can be obtained, an increase in ωM produced by an increase in ω has quite a different effect. The inherent nature of the variation in amplification with frequency is quite obvious.

Screen-grid tube circuits are similar

Similar characteristics are to be found in amplifiers using the screen-grid tube. The plate impedance of these tubes is so high that conditions seldom exist under which it is possible to realize the optimum amplification characteristics. The square of the mutual impedance, if the coupling between circuits is by means of a transformer,

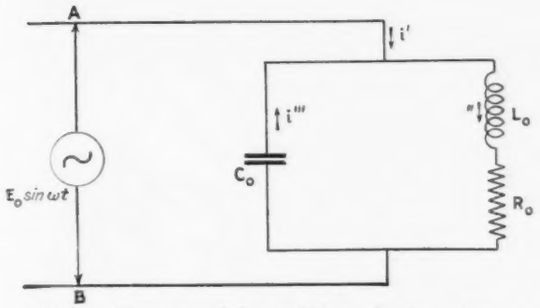


Fig. 2—Circuit used for solution of the problem of uniform amplification

is usually but a small fraction of the product of the tuned circuit and plate resistances. For this reason a close approximation to the amplification obtained is given by the product of the mutual conductance of the tube and the load resistance. If the coupling from one tube to another is by means of a tuned impedance the load resistance is given by $\frac{\omega^2 L^2}{R_2}$. The amplification is then proportional to this term. Since R_2 seldom varies at a greater rate than the first power of the frequency at low frequencies, and at only a slightly higher rate at the higher frequencies, this term can be considered to vary approximately as the first power of the frequency. Accordingly the amplification when screen-grid tubes are used varies at even a greater rate than when other tubes are used. The variation for a single stage may be almost three to one over the broadcast range, and for a two- and a three-stage amplifier the value of the variation will be the square and the cube of this value respectively.

These causes of variation in amplification, which are inherent in the amplifier, cannot be eliminated by any straightforward application of amplifier principles. Therefore when an amplifier is to be used over a wide range of frequencies something more than a simple amplifier is required. Means, which are not a part of amplifier design as such, must be employed which will introduce a certain amount of uniformity in the amplifier characteristic at various frequencies. It is these methods which will be discussed at this time.

Studying the amplification equation we observe that the symbol denoting the mutual inductance of the amplifier appears in the numerator. A method of introducing uniformity in amplification suggests itself immediately. If the mutual inductance can be made to vary in some desired fashion a partial or complete compensation for other variables in the equation may be obtained. Obviously this method is worthy of investigation. We will find, after the investigation has been made that a partial application of the method has been used many times in the past, usually unknown to the research engineer.

Introducing uniformity of amplification

The method used is characterized principally by the introduction of a tuned circuit in series with the primary of the radio-frequency transformer which is coupled inductively to the secondary coil of the transformer with a coupling 180 deg. out of phase with the principal coupling to this coil. The illustration of Fig. 1 shows the arrangement in detail. It is evident that the effective coupling between primary and secondary is a function of the frequency. The rate and sign of the variation is not so obvious, and a solution of the circuit equations is necessary. This solution will yield the design information required, and will increase considerably the ease with which the desired results may be obtained.

A study of Fig. 1 shows that the arrangement consists essentially of three circuits and three sets of mutual impedances. Using the notation of this figure we write down the circuit equations

$$\left[R_0 + L_0\frac{d}{dt}\right] i_0 + \left[R_0 + R_1 + R_2 + L_0\frac{d}{dt} + L_1\frac{d}{dt}\right] i_1 + \left[M_0\frac{d}{dt} - M_1\frac{d}{dt}\right] i_2 = \mu E_g e^{j\omega t}$$

$$\left[R_0 + L_0\frac{d}{dt} + \frac{1}{C_0}\int dt\right] i_0 + \left[R_0 + L_0\frac{d}{dt}\right] i_1 + M_0\frac{d}{dt} i_2 = 0$$

$$M_0\frac{d}{dt} i_0 + \left[M_0\frac{d}{dt} - M_1\frac{d}{dt}\right] i_1 + \left[R_1 + L_2\frac{d}{dt} + \frac{1}{C_2}\int dt\right] i_2 = 0$$

The solution for i_2 due to E_g is not sufficiently simple to be used with facility, and accordingly another method of solving these equations will be used. The problem is unlike ordinary three-circuit problems in that not only does a mutual impedance exist between the first and second, and the second and the third circuits, but also between the first and third circuits.

We will obtain an approximate solution of these equations in the following manner. Assume an alternating e.m.f. $E_0 \sin \omega t$ impressed between the points A and B of Fig. 2. A current i' will flow in the principal circuit having the value

$$i' = \frac{E_0 \sin \omega t}{\frac{j\omega L_0 + R_0}{1 - \omega^2 L_0 C_0 + j\omega R_0 C_0}}$$

In the inductive branch of the parallel circuit there will be a current

$$i'' = \frac{E_0 \sin \omega t}{j\omega L_0 + R_0}$$

and in the capacity branch

$$i''' = j\omega C_0 E_0 \sin \omega t$$

We are interested in the ratio of i''' and i'

$$\frac{i'''}{i'} = \frac{1}{1 - \omega^2 L_0 C_0 + j\omega R_0 C_0}$$

This ratio is a function of the frequency, and as a consequence the tuned circuit $L_0 C_0 R_0$ located with reference to the principal circuits as shown in Fig. 1 may be considered simply as an arrangement for obtaining a variation of the current in a mutual impedance ωM_0 according to a predetermined manner. But a current varying as a function of the frequency in a fixed circuit parameter can be replaced by a fixed current in a variable circuit parameter. Therefore in place of M_0 we may consider a mutual inductance of the value

$$M' = \frac{M_0}{1 - \omega^2 L_0 C_0 + j\omega R_0 C_0}$$

Since this mutual inductance is of the opposite sign to the inductance M_1 the total effective mutual inductance in the circuit connecting the currents i_1 and i_2 is

$$M = M_1 - M' = M_1 - \frac{M_0}{1 - \omega^2 L_0 C_0 + j\omega R_0 C_0}$$

Now if the frequency at which the amplifier is used is always below the frequency for which

$$\omega^2 = \frac{1}{L_0 C_0}$$

the value of M, the effective mutual inductance, will decrease with increasing frequency. The values of L_0 and C_0 can be so chosen that this condition for ω is fulfilled throughout the operating range. Also, the rate

at which variation with frequency will take place will depend on the product of the values of L_o and C_o. A proper choice of M_1,M_o, and the product L_oC_o will give to M any desired value at any frequency in the broadcast range as well as the desired change in this value with change in frequency.

For a single effective mutual inductance M, the amplification has been found to be equal to

$$\text{Amplification} = \frac{\mu\omega^2 ML}{\omega^2M^2 + R_pR_2}$$

In deriving this equation all impedances in the primary circuit with the exception of R_p have been neglected. Therefore we may use for the value of M in the amplification equation the effective value

$$M_1 - \frac{M_o}{1 - \omega^2L_oC_o + j\omega R_oC_o}$$

only on the supposition that the impedance of the tuned circuit $L_oC_oR_o$ is small compared with R_p. This is not a serious limitation. In selecting values for L_o and C_o, it will in general be found advisable to place the resonant frequency of this combination of circuit elements well out of the broadcast range. Consequently the impedance is small compared with the value of the resistance R_p.

We are now ready to see how the equations for amplification and for effective mutual inductance may be used together. We have seen that the value of the amplification increases with increasing frequency. We may wish to know now the condition under which the amplification will decrease with decreasing M. The derivative with respect to M of the amplification equation is positive when

$$R_pR'_2/\omega_o > \omega M^2$$

and negative when

$$R_pR'_2/\omega_o < \omega M^2$$

where R_2 is considered to vary directly as the frequency, but has the value R'_2 at the lowest frequency $\frac{\omega_o}{2\pi}$ of the broadcast band. Therefore the amplification decreases with decreasing M throughout the broadcast band if at every frequency in this range

$$R_pR_2 > \omega^2M^2$$

This condition is nearly always satisfied. In amplifiers using the screen grid tube this condition is not only satisfied, but the value of R_pR_2 is so large compared with ω^2M^2 that the amplification varies very nearly inversely as the coupling.

We are now ready to determine the approximate values of M_1 and M_o for an amplifier using the screen grid tubes. If in the tuned circuit in the series with the primary coil $\omega^2L_oC_o << 1$ for the highest frequency of the broadcast band, a simplification in the equation for the effective mutual inductance of the circuit may be introduced and the equation written as follows:

$$M = M_1 - \frac{M_o}{1 - \omega^2L_oC_o}$$

We will now determine the values of M_1 and M_o to be used in a particular amplifier. Experience tells us the value of the ratio of the amplification at the highest broadcast frequency to that at the lowest frequency in a particular amplifier. Let this ratio be denoted by k. Now introducing the circuit modification of Fig. 1 we will require a change in the effective mutual inductance over this range of frequencies which expressed as a ratio may also be denoted by the symbol k. It should be remembered that this simple procedure is possible only

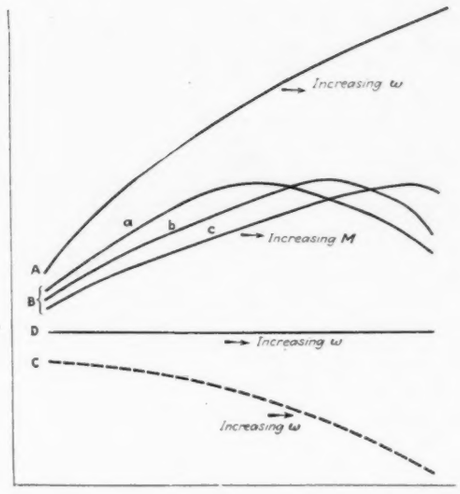


Fig. 3—Curve A—Variation in amplification with frequency

Curve B—Amplification as a function of M for values of R_pR_2 increasing in the order a, b, c
Curve C—Required variation in M needed to approximate ideal Curve D

in the case of the screen grid tube. For all other tubes the change required in M will differ considerably from the value k. Since the ratio of the effective mutual inductances at the highest and lowest frequencies is equal to k, we have

$$\frac{M_1 - \frac{M_o}{1 - \omega_1^2L_oC_o}}{M_1 - \frac{M_o}{1 - \omega_2^2L_oC_o}} = k$$

where ω_2 corresponds to the highest frequency and ω_1 to the lowest frequency. L_o and C_o are chosen on the basis that $\omega^2_2L_oC_o < 1$. M_1 is chosen generally as the largest possible mutual inductance obtainable. This equation then gives the required value of M_o.

When other than screen grid tubes are used the value of M_o is selected with slightly greater difficulty. The easiest method is perhaps one of selecting a set of values; determining from this set a value of M at the highest frequency and another value for the lowest frequency; and then substituting these values of M in the amplification equation, determining a value of the amplification at two different frequencies. In making this substitution different values of R_2 must be used for the different frequencies. This process may be carried out until a set of values for M_1, M_o, C_o and L_o are found that give a constant value for the amplification.

These equations will probably simplify to some extent the work of designing radio-frequency amplifiers of uniform amplification characteristics. They are directly applicable to amplifiers using the screen grid tube, and as a consequence they are especially valuable at this time when the use of the screen grid tube is almost universal in radio-frequency amplifiers. Similar results may be obtained directly in the laboratory by experiment, but a small amount of computation using these equations will greatly facilitate the work. One might add, furthermore, that these equations and the methods by which the circuit of Fig. 1 has been solved give an interpretation of the functioning of this circuit, which, if a more rigorous method of solution had been used, might have been considerably more difficult, or practically impossible.

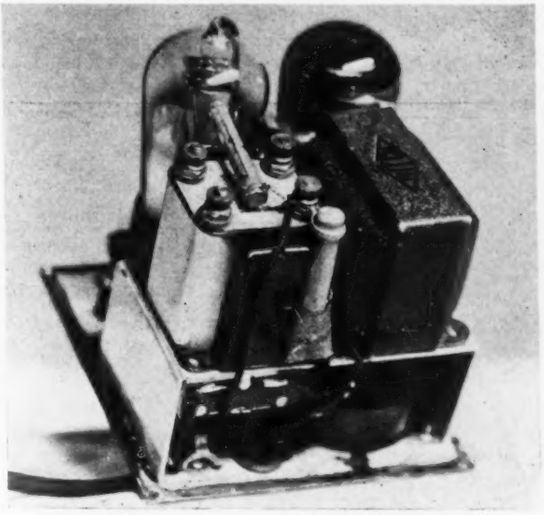
A dual-frequency audio source for general laboratory use

By G. F. LAMPKIN

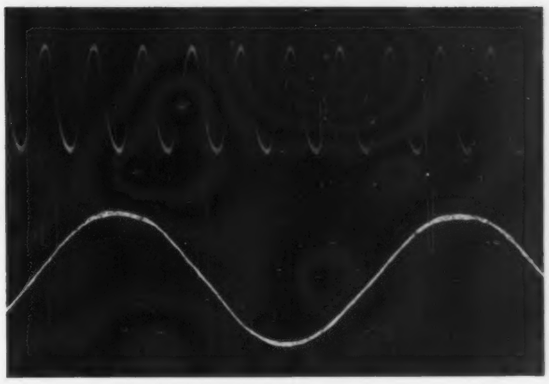
IF A continuously variable source of audio frequency be desired, a beat-frequency oscillator is a most suitable instrument. There are other times, however, when only a single audio frequency is needed, and a beat-frequency oscillator is either too bulky or too expensive.

At such times a dynatron oscillator of the sort described below is adequate. It has been designed to be most compact; to give a wide range of output voltages; to give one frequency near the center of the musical range, and another near the center of the voice range; to be nearly independent of the nature of the load; and to give a sinusoidal wave form.

The times when a single-frequency audio source is of use include those when bridge measurements are necessary; when sensitivity and selectivity tests on radio receivers are made; when tone modulation is needed on radio transmitters; or when various transmission networks—amplifiers, filters, long lines—are to be studied.

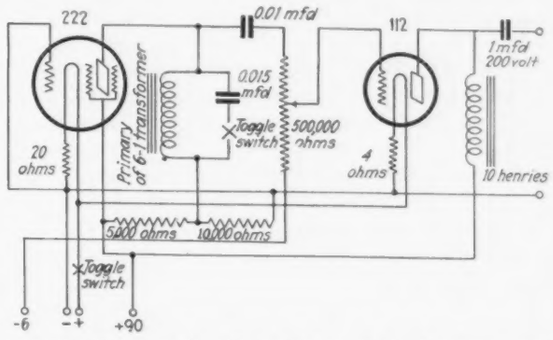


The oscillator is very compact; it is contained in a box five inches square



Comparison of the wave form with a 60-cycle timing wave of the 415-cycle output

The schematic circuit of the unit is drawn in the figure



Circuit diagram of audio oscillator of the dynatron type

The UX-222 screen is used as a dynatron oscillator because of the simplicity of the circuit, the ease of oscillation at audio frequency, and the purity of wave form. Two resistors are used to place the correct plate voltage on the UX-222, and thus eliminate one battery tap and connection. The oscillator feeds through a voltage-controlling potentiometer to the output tube. The latter is used to isolate the dynatron from the load. A choke and condenser filter keeps the d.c. from the output.

The operating voltages shown are for a 222 and a 112 tube. A 171-A may be used for the output tube if a higher voltage is desired, since there is ample input from the oscillator. The new 2-volt 230-series tubes would be excellent for enhancing portability of battery supply.

Using the constants and apparatus as above, the two frequencies are approximately 415 and 1060 cycles. The 1060-cycle note increases 4 per cent with filament voltage change of 4.5 to 5.5 volts; and decreases 20 per cent with a 90 to 112-volt plate-voltage change. With 90 volts plate the output voltage range on a 13,000-ohm load is from overload on the 112, or about 30 volts peak, down to around 15 millivolts. Lower output can be obtained by using a potentiometer on the output. Higher output calls for a 171-A-type tube. The wave form of the 415-cycle output is shown in figure, accompanied by a 60-cycle timing wave. The film was taken with 22.2 volts r.m.s. across the primary of a stepdown transformer working into the oscillograph vibrator.

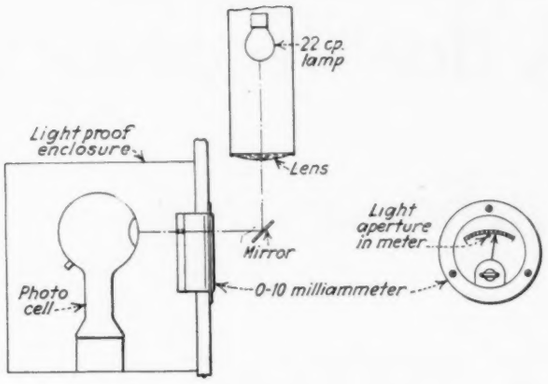
Phototube voltage supervisor

An aid to tube production

By W. P. KOECHEL*

EACH of the 40 test tables in the radio tube factory of the Ken-Rad Corporation, Owensboro, Ky., was until recently equipped with individual batteries, voltage controls, and voltmeters. Under these conditions, requiring constant attention and maintenance, it was extremely difficult to keep the test tables in such a condition that those tables testing similar apparatus would check each other consistently. To meet this problem, an automatic master voltage control has been developed which depends upon the simple action of a phototube. There are 17 different voltages in constant use for the grid, plate, and filament voltages of the tubes under test. These voltages now originate from a central bank of storage batteries, from which the desired voltages are tapped and carried to separate receptacles in the test tables.

The voltages are all adjusted and controlled from a central control panel, thus eliminating the voltmeters and voltage controls on the individual test sets. In order that the 17 independent voltage settings at the master control panel may be properly supervised, an ingenious automatic alarm system was devised whereby an instant alarm, both visual and audible, is given whenever any voltage supply is higher or lower than its specified value. The accuracy of this scheme is such that an indication of one per cent above or below normal will give an immediate alarm. This is accomplished as shown in the accompanying illustrations by the use of a phototube in conjunction with a master monitoring meter and a commutating device by which this monitoring meter is successively connected to each of the voltage circuits being supervised.



Arrangement of phototube and meter

The master monitoring meter is an 0-10 milliammeter arranged by means of proper series resistors to read exactly 5 ma. whenever it is connected to any voltage circuit for supervision providing that circuit is adjusted to its normal voltage. At exactly the 5 ma. point on the scale of this meter a small hole is drilled through the dial and another hole exactly in line with it is drilled in the case of the meter. Over the front of the meter, suspended by a bracket, is a tubular case containing a 22 candlepower lamp and a suitable lens for focusing the light rays, by means of a mirror, on the aperture.

If the pointer of this master monitoring meter indicates any value other than 5 ma., the focused rays from the lamp will pass through the aperture on the meter scale and impinge on the phototube. However, if the pointer indicates exactly 5 ma., it will obstruct the passage of the ray of light and the phototube will be "dark."

This phototube is connected to the input of a vacuum tube amplifier in such a manner that the action of light on the cell will increase the negative bias on the amplifier tube and reduce the plate current to a negligible value. In the plate circuit of the amplifier tube is a relay which is continuously energized as long as the phototube is in a "dark" condition. The operation of the photo cell causes this relay to drop to the non-operative condition, energizing a second relay which in turn operates a large pilot light and gong. This second relay also acts to disconnect the motor driving the commutating device. In addition, there are a number of small pilot lights, one for each voltage circuit being supervised. These small pilot lights indicate which particular circuit is indicating an abnormal voltage.

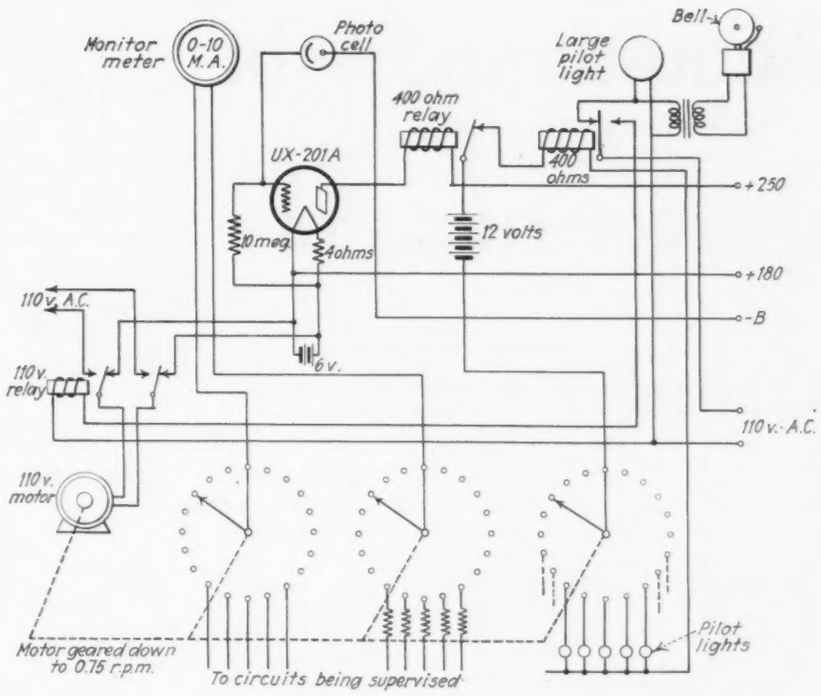
The monitoring meter is connected in proper sequence to each circuit for about three seconds in every 80 seconds. The commutating device, mounted on the rear of

IN A tube manufacturing plant the problem of supplying correct and uniform voltages to the test positions is important. An ingenious solution is to apply a phototube to monitor these voltages and to give warning when abnormalities occur. The method can undoubtedly be applied to any production problem where movements of a current meter needle indicate a proper or improper condition.

*Engineer in charge of Test Department, the Ken-Rad Corporation, Owensboro, Ky.

the control panel, consists of three sections of 20 contacts each, together with three rotating arms and brushes. Two of these commutators make the connections to the monitoring meters, while the third operates the alarm signals. The circuit is so arranged that when the phototube alarm feature functions, the motor stops at that point, and causes the pilot light corresponding to the circuit in trouble to stay lit until the trouble is corrected. In order to prevent the motor from coasting beyond the proper commutator point after the current is cut off, an electric braking scheme is utilized, in which 6 volts d.c. is applied to the motor at the instant that the 110 volts a.c. is removed. This acts as a very effective and silent brake, and the speed at which the motor decelerates can readily be controlled by varying the applied d.c. voltage.

The accompanying diagram shows the apparatus connections.



In using this master control system, the voltage values are first adjusted manually at the control panel. As each voltage circuit is supervised once every 80 seconds, it is almost impossible for an abnormal voltage condition to persist. When the alarm is sounded, the faulty voltage is manually reset to its proper value.

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ELECTRONIC RECORDING OF HIGH-SPEED PROJECTILES

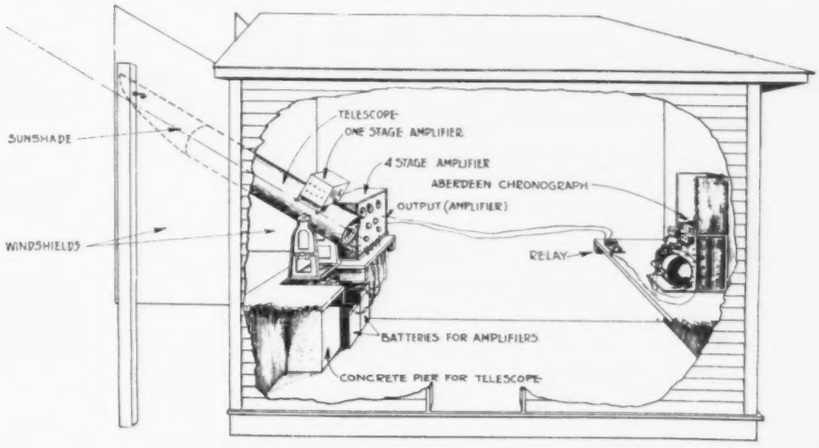
New applications of the photo-electric cell and the vacuum tube have been found in the testing of government military equipment, in ways that may suggest civilian and industrial uses.

The photo cell, in one instance, serves with a powerful amplifier to obtain an automatic record of the time of flight of anti-aircraft projectiles. The amplifier in this apparatus is so arranged that it causes a spark to perforate a piece of paper which is carried on the drum of a slow-motion Aberdeen chronograph. When the gun is fired, the light from the muzzle flash causes the first spark to jump, and the burst of the projectile at a remote point of the trajectory causes the second spark. This apparatus has functioned satisfactorily for night firing but with less certainty in the daytime, because of the great sensitivity required.

The photo-electric cell has also been applied to the measurement of velocity of projectiles. The apparatus is so constructed that when the projectile passes overhead, a reduction in the light which impinges on the cell is recorded by means of an amplifier on an oscillograph or other instrument. This method of measuring velocities is especially suitable for the measurement of the velocity of large guns at angles of elevation too great for convenient use of the solenoid chronograph.

To obtain a record of the impact of inert bombs on the ground in connection with ballistic data and also to record the delay of bomb fuses, a very sensitive apparatus based on vacuum-tube oscillations has been made. The ground shock from the impact of bombs, slight as it is, causes a change in the distance between two metal plates, whose capacity forms part of the oscillating circuit. This apparatus has been found sensitive enough to record the impact of 17-lb. bombs on rather soft ground at a distance of 1,200 feet from the apparatus. The impact of heavier bombs can be recorded with certainty at a distance of a mile or more from the station.

For testing small arms a closed range for the purpose of obtaining a series of spark photographs at different points along the trajectory of a given bullet and of measuring the retardation by photo-electric cells has been constructed and is now being equipped at the Aberdeen proving ground.



Acoustic and light characteristics of sound screens

By BARTON KREUZER*

DUE to the advent of sound motion pictures the choice of picture screens for theater use has become increasingly important. The factors governing the choice of a screen are several. They may be divided into two general classes, i.e., the merit of the screen judged by its technical performance, and its serviceability.

Under the latter class, such points must be considered as: the type, weight, and strength of the material, its inflammability, whether it collects dust easily and is difficult to clean, whether it will fade, crack or discolor and the amount of handling it will stand. The last point is of especial importance with beaded and mesh screens. All of the factors in this class may be tested both without a great deal of technical knowledge or equipment.

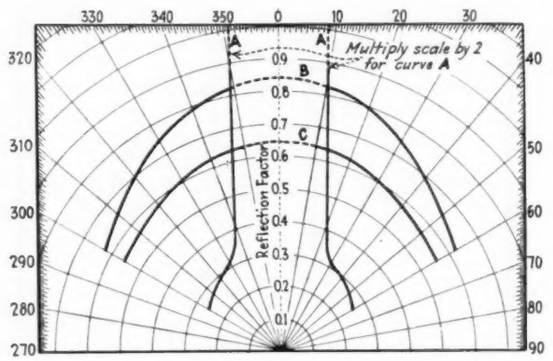
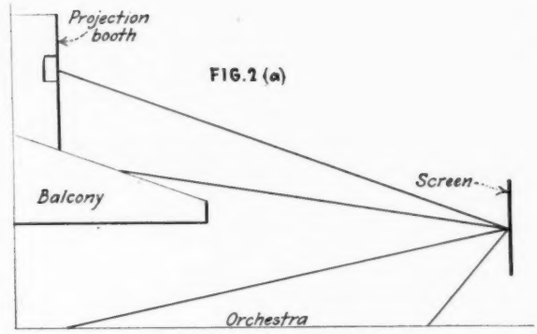


Fig. 1—Typical brightness curves for different screens. Note rapid "fadeout" of the beaded screen shown by curve A

The merit of a sound screen from a technical viewpoint is based on two characteristics. These are the "brightness" characteristic and the "acoustic transmission" characteristic of the screen. The "brightness" characteristic of a screen may be defined as the intensity of illumination of the screen plotted for various angles from the illuminating beam. There are two general methods for



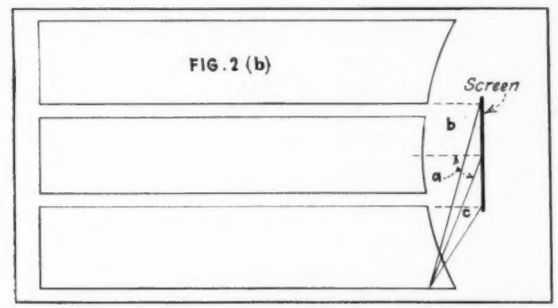


Fig. 2 (a), (b) Limiting projection and viewing angles in a theater. These angles determine the best screen from its light characteristics

obtaining the "brightness" curve for a screen. The first of these is by the use of some photometric comparison instrument, such as an illuminometer, where the eye of the observer is called upon to match two brightnesses. The second method is by the use of a photoelectric cell.

Methods for obtaining light intensities

The photoelectric cell can be used in two ways. In one method it can be used "statically" to measure the brightness at various angles of a normally incident light beam. With a large resistance in the circuit the cell can be adjusted for linearity over a fair range of intensities and can be employed to vary the bias on a vacuum tube voltmeter.

In the second method if a rotating wheel cut so as to cause sinusoidal variations in the light intensity be placed in the path of the incident light beam, then a lower intensity source may be used, as a quite conventional audio frequency amplifier will amplify the photoelectric cell output to the point where meter readings are convenient. This is much more convenient than using the d.c. amplifier necessary with the same illumination, for the "static" method. A greater linear intensity range is also available with the dynamic method since the cell may be polarized through a transformer eliminating any appreciable change of anode potential with incident light intensity.

Difficulties in using photo-cells

The chief disadvantage of the illuminometer method is the possibility of error introduced by the human observer. The disadvantages of the photoelectric method are: the additional equipment, the greater light intensity necessary, the lack of uniformity of cell sensitivity and the cell color sensitivity characteristic which may discriminate unfairly against certain screens.

This last reason is important because in the final

*Research engineer, RCA-Photophone, Inc.

analysis the brightness of a screen is judged by the human eye, the color sensitivity of which is a broad peak in the yellow portion of the spectrum with less response at the blue-violet and red ends of the spectrum. Practically all of the present photoelectric cells, whether red sensitive, merely possess a peak in the blue region, or even when they are yellow sensitive do not match the color sensitivity of the eye. Because of this a screen absorbing either end of the spectrum may be unduly penalized by accepting its rating from a photoelectric cell test, because the eye bases its judgment chiefly on the yellow region in which only very slight absorption may occur.

With a visual (photometric) instrument method although the eye may have difficulty matching intensities of different color characteristics, yet, a small amount of experience will enable the observer to obtain accurate results by adjusting the instrument to secure a "fading" of the line of demarcation between the surface illuminated by the working standard and the image of the surface under test.

With either method the procedure is to [illegible] spot of light on the screen, free from color or filament image, and incident normally both horizontally and vertically. Measurements are then made of the brightness as close to the beam as possible and progressively away from it in the arc of a circle.

Obtaining typical brightness curves

The curves in Fig. 1 have been obtained with an illuminometer in this manner and later checked with the photoelectric cell method. In some cases it may be necessary to take characteristics with the light beam at another angle than normal, but usually the results of such tests can be predicted from the normal curves.

The curves are plotted in polar form and are in terms

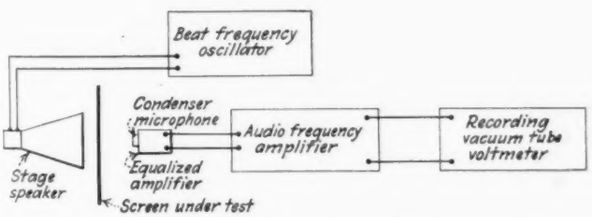


Fig. 3—Set-up of sound measuring equipment for determining acoustic qualities of screens

of a "reflection factor." The use of a reflection factor as a unit provides a more intelligent understanding of the screen's properties and makes direct comparisons easy. The reflection factor for a perfectly diffusing mat surface is unity. Where curves rise above unity the situation is not paradoxical for a spherical distribution is being considered and at certain angles these surfaces may diffuse light poorly and verge on direct totally reflecting surfaces. Conversion to a reflection factor has been accomplished by taking readings on a standard calibrated opal test plate whose reflection factor was known.

Actually observed curves for representative screens are shown in Fig. 1. No actual points are shown to closer than 10 deg. from the normal because of the obvious difficulty encountered when the test equipment obstructs the light beam source.

Curve *A* shows the characteristics of a typical beaded

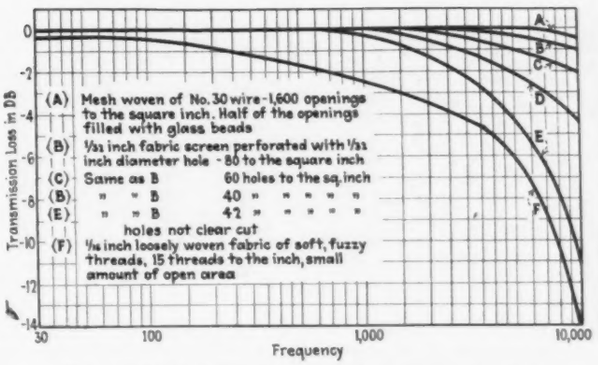

Transmission Loss in DB
0
-2
-4
-6
-8
-10
-12
-14
30
100
1,000
10,000
Frequency
A
B
C
D
E
F
(A) Mesh woven of No. 30 wire - 1,600 openings to the square inch. Half of the openings filled with glass beads
(B) 1/32 inch fabric screen perforated with 1/32 inch diameter hole - 80 to the square inch
(C) Same as B 60 holes to the sq. inch
(D) " " B 40 " " " " "
(E) " " B 42 " " " " "
holes not clear cut
(F) 1/16 inch loosely woven fabric of soft, fuzzy threads, 15 threads to the inch, small amount of open area

Fig. 4—Typical sound transmission curves showing losses in decibels for different types of screens

screen. Note the high value for the first few degrees and the rapid "fadeout" making it suitable for use only in a narrow theater where no patron will be at a very great angle from the normal. This type is preferred for a house with a large balcony since the point of maximum brightness always lies along the incident beam whether it be normal or inclined. With the light coming from a projection booth above the balcony this insures good screen illumination for the balcony seats. This type of reflection is due to the spherical globules used as "beads."

Curve *B* shows the characteristics of a reflecting type screen. Note its greater uniformity over large angles and its freedom from "fadeout." This makes it quite suitable for use in large, wide, theaters. With this type a maxima is observed along the incident beam with a slight, secondary maxima at the angle of reflection (an angle from the normal equal to the angle of incidence) due to a slight mirror effect.

The type of curve obtained from a diffusing screen does not differ appreciably from that of curve *B* except that when the light is not thrown on normally the slight maximum point occurs along the incident beam without any secondary maxima. It more closely approaches a perfect diffusing surface.

Curve *C* has been obtained from a special type of "beaded" screen. Here the "beads" are glass cylinders whose height is about equal to their diameter. These disks are embedded in the screen material and give a very uniform "brightness" characteristic although with reduced efficiency.

Figs. 2 (*a*) and (*b*) show the angles to be considered in choosing the right screen for a theater. In Fig. 2 (*a*) (vertical cross-section) the angles to be considered are obvious, but in Fig. 2 (*b*) (horizontal or plan view) the angle (*a*) not only of the furthest seat with the center of the screen must be considered, but also the angles (*b*) and (*c*) that opposite sides of the screen subtend at that seat. Care must be exercised not only to prevent distortion and "fadeout" due to the large possible difference between angles "*b*" and "*c*" but also to prevent fatigue to the eye due to great differences in the apparent intensity of illumination at these points.

Measuring acoustic characteristics of screens

The "sound transmission characteristic" of a screen is the variation with frequency of the sound transmitted through the screen. To obtain these characteristics response curves were taken on standard theater loudspeakers with a beat frequency oscillator, using sound

measuring recording equipment, both with and without a screen being present. By careful selection of an acoustically treated room and the use of many check curves, the effects of reverberation, standing waves, and "stray" reflections were successfully minimized. The screen when placed in front of the loudspeaker was put in exactly the same position as it would be in a theater installation. This meant that the screen was sufficiently removed from the speaker mouth to prevent any reaction upon the speaker which might alter its response and lead to incorrect measurements. It will be noted that the curves obtained in this manner were quite regular and smooth.

The schematic diagram of the sound measuring equipment is shown in Fig. 3. The beat frequency oscillator has a logarithmic variation of frequency from 30 to 10,000 cycles with uniform rotation of its dial. Its output is fed to the stage type loudspeaker, consisting of an electro-dynamic cone unit, and a directional baffle. In front of this is the screen under test. The sound pressure is converted by the condenser microphone into electrical energy and amplified in an associated amplifier which is equalized to correct for the frequency characteristic of the microphone. After further amplification the output is fed to a vacuum tube voltmeter. A drum carrying logarithmic frequency paper is geared to the beat frequency oscillator. As the frequency is varied this drum revolves and an ink trace is left by a pen connected by linkwork with a pointer pivoted over the output meter of the voltmeter. By means of a handle attached to this system the observer is able to make the pointer follow the variations of the meter and leave a trace on the drum proportional to the speaker response at any point over the frequency range.

The relatively linear vacuum tube voltmeter (any slight non-linearity is corrected in the mechanical system) is obtained by using a UX-864 with $E_p = 45$ volts, $E_g = -3.0$ volts, making the output meter insensitive by shunting it down and using a large input. This input may even drive the grid positive. Linearity is adjusted for individual tubes by the variation of a series grid resistor of from 5,000 to 20,000 ohms. With a transformer input this may not be necessary.

Types of sound screens available

Fig. 4 shows the sound transmission characteristics of several screens. These curves show the loss in decibels for different screens under test. In general the screens are 100 per cent efficient for the lower frequencies and then gradually fall off. This is comparable to the situation in an electrical transmission system where a series element which reduces the current flow 20 or 30 per cent at 5,000 cycles may not cause any decrease below 500 or 1,000 cycles that can be measured with conventional instruments.

Curve *A* in Fig. 4 shows the transmission for a screen with a "mesh" backing. This is ideal for sound purposes but unfortunately it is one of the beaded screens whose characteristic is of the type shown by curve *A*, Fig. 1. This naturally limits its use. Curve *B*, *C* and *D* show the characteristic of well-perforated screens of satisfactory brightness qualities. These are very widely used screens.

Curve *E* shows the characteristic of a poorly perforated screen. The holes in this screen were not "clean cut."

Curve *F* shows the absorption in a woven screen due to the use of soft "fuzzy" thread. Lint from this thread blocks the openings in the material and causes dissipation of the sound.

The electrical analogue of the usual sound screen may be considered as an inductance of very slight resistance placed in series with a transmission network. The values of the inductance and resistance are a function of the dimensions of the holes in the screen and their density. The values of inductance and resistance increase as the holes become tube-like, i.e., as their length approaches or becomes greater than their diameter. This may be due, of course, to thick screen material or small hole size. The value of resistance may also be increased by the presence of poorly perforated holes with "frayed" edges or holes clogged with lint or dust to cause dissipation. The effect of the perforations on the light qualities of screens is approximately linear, i.e., with 10 per cent of the screen area occupied by perforations the reflection factor at any angle is reduced to approximately 90 per cent of its value for an unperforated like surface.

The effect on sound transmission is different, however. This same percentage of holes may transmit as much as 80 per cent of the sound at 5,000 cycles.

Although a slightly lowered reflection factor can be overcome usually by greater light from the projection booth the perforations introduce an intangible effect upon the picture because of the "greying" of the screen surface. This is due, very often, not only to the holes themselves but also to the view of the darker material forming their side walls, which the audience may unconsciously perceive.

It is obvious that good screens require the best of technical skill in design. To be quite ideal a screen should have a high reflection factor reasonably constant over large angles, be free from diffraction and specular reflection, and transmit sound satisfactorily up to 10,000 cycles, as well as be sufficiently rugged to withstand theater use.

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ELECTRONIC MUSIC IN THE SPOTLIGHT

THE musicians in a symphony orchestra, the performers in a popular band, and the musical artist in the home, have suddenly found a strange and startling novelty—the electrical musical instrument. Into the realm of music, where for so many centuries instrumental progress has been largely along conventional and time-honored lines, the electron suddenly comes to the middle of the stage and waits for the spotlight of public interest which soon will blaze upon it.

—DR. A. N. GOLDSMITH

▲

The importance of

Phase control in synchronizing

By C. W. HORN*

SYNCHRONIZATION of two or more broadcasting stations transmitting the same program involves the solution of two important problems, that of keeping the stations on the same carrier frequency, and that of maintaining them at some constant phase difference with respect to each other. While it has been recognized that the carrier frequencies must be identical and must be maintained so, it is only recently that the importance of constant phase difference was discovered. This phase difference need not be zero, it can, as a matter of fact, be anything so long as it is unvarying, or at least varies at a very slow rate.

For a number of years, WBZ and WBZA have been "synchronized," i.e., they have been on the same carrier frequency and have transmitted the same program simultaneously with each other without noticeable interference with each other. Here, however, conditions were not those to be generally experienced. Ordinarily any stations operating on approximately or even exactly the same frequency created an area between the stations in which considerable distortion was evidenced. This distortion was due to the fact that the ground waves of the two stations at times opposed each other, thus giving a resultant strength of signal which was very low; while at other times they might aid each other by being in phase, thus creating a stronger signal.

The WBZ installation

In the WBZ-WBZA area, however, there were special and most favorable conditions operating in the region between the two transmitters, in which listeners would ordinarily experience "mush" where neither station can be heard, and so nothing was lost so far as they were concerned. At the same time, neither station is able to transmit its carrier over the barrier which exists.

Experiments have been conducted for a number of months to determine the feasibility of synchronizing such high-powered stations as WEAF, WGY, and KDKA. On a number of occasions these stations were actually tied together transmitting the same program under the same technical conditions as exist at WBZ and WBZA, i.e., frequency synchronization. Peculiar results were at once apparent which made it evident that maintenance of the same carrier frequency was not sufficient no matter how exactly it was performed.

For example, within the service area of WEAF bad interference was experienced from the other two stations when all were transmitting identical programs on the same carrier. It was evident that the carrier waves of the other stations were destroying the program emanating from the local station, WEAF.

When, however, the stations were maintained not only at the same frequency but in a fixed phase relation, several important and encouraging events transpired. No longer was the program coming to local listeners from WEAF disturbed; the mush area disappeared, and those listeners in this area experienced an increase in local field strength. Apparently when one of the stations was fading out, another, or both of the others might be fading in. It was certain that the average field strength was no worse and nearly always better—some of the fading hollows had been filled in.

Neutralized point of interference

At various places out in this area, usually characterized by "mush," the ground waves of two stations may create what might be termed a "neutralized point" if they meet head on and are 180 degrees out of phase. Theoretically, no field strength exists at this point but fortunately such a "neutralized point" is sharply defined, and of only a few meters extent. Therefore, any ordinary antenna will cover an area greater in extent, and thus will receive sufficient energy. Experience indicates that so long as the phase displacement of the synchronized carriers is constant or varies very slowly, the listener will be better off than if the stations were not synchronized. Depending upon location and distances, the listener will benefit by a better average field strength, because it is unlikely that all of the synchronized stations would fade out at the same moment—even in this contingency, reception would be in no way worse than if only a single station were transmitting the program on that particular frequency.

Thus far we have looked only at the technical problem and the results of experiments carried out with the cooperation of the National Broadcasting Company, the Radio Corporation of America, and the American Telephone and Telegraph Company. The difficulty of putting into practical operation any number of synchronized stations, whether to cover sections of the country or the whole country, is one that must be studied carefully in each individual case, for it involves many factors, including wave allocations and more particularly, highly important economic considerations.

▼

THIS statement by the engineer who for years has been studying and advocating "synchronizing," tells how the dream of all broadcasting engineers has at last been achieved.

▲

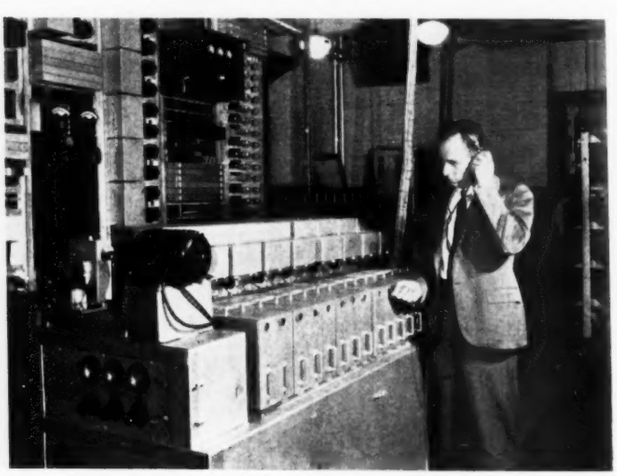
* General Engineer, National Broadcasting Company, Inc.

Voice number calls from dial phones

By PAUL B. FINDLEY*

FUNDAMENTAL research in the fields of electronics and thermionics has long been conducted by Bell Telephone Laboratories and has resulted in such devices as the telephone repeaters which make possible long-distance telephony. A recent and extremely interesting development in this field is the "call announcer," which transforms into speech the pulses produced when you dial a telephone number.

The necessity for apparatus of this nature is a result of the present transition period from manual to dial operation of telephones. If you were to dial the number of a telephone connected with a manual exchange, you would cause a series of pulses to pass over the wires to an operator in that exchange. These pulses, however, are absolutely unintelligible to the operator, and there must be present some means of translating them into a signal which she will understand and which will give her sufficient information to set up the desired connection.



The "call announcer" in use. Below the motor-driven sound-film units can be seen the associated amplifiers. At the left are operating meters and controls

When this problem first arose, it was solved by the use of "call-indicators" in which the pulses from dial telephones caused certain numbers and letters to be displayed before the operator. There were limits to the use of this apparatus, however, and it became necessary to develop supplementary apparatus. Due to the work of the Laboratories on sound-picture systems, there was available considerable sound-picture apparatus, and an investigation was therefore made of the possibility of translating dial pulses into speech.

The result of this work was the call-announcer, which, as finally developed, consists of eight drums. One of these is a spare and the other seven carry on their outer edges fourteen strips of film, on each of which is recorded one of the ten digits or one of the four call letters, J, M, R, W. These drums are mounted on a common shaft and driven by a small motor. In front of each film is a small lamp which is focussed on it, and behind the film and within the drum is a photoelectric cell of the type developed for sound pictures.

For any apparatus designed for use in the telephone system, length of life is very important. Fortunately, the shortness of the individual records used in the call-announcer makes it possible to clamp the short strips of film to the drums, thereby eliminating the friction and wear of the sprockets and gates, which is unavoidable in showing sound pictures. Under the conditions met with in the call-announcer, film need be replaced not more than once a year.

Long life of tube and film elements

The question of replacements also arose in connection with the lamp and photoelectric cell, which, as used in a sound-picture projector, have a life of about 100 hours. In a call-announcer, due to their continuous use, these elements would have to be replaced too frequently for economical operation, and a departure from sound-picture operating technique has therefore been made for the purpose of decreasing the necessary number of replacements. This departure consists in operating the lamp at a much lower illumination level, thus obtaining a longer operating life for lamp and cell. As a result, the average life of these elements in a call-announcer under normal conditions is about 200 days.

Due to the lower illumination level of the lamp, however, the current from the lamp is of much lower intensity than in sound picture practice. For this reason, a three-stage amplifier is associated with each of the fourteen systems, and is located immediately beneath and in front of the drums. On passing through these amplifiers, the current is raised about fifty decibels and is then fed into telephone repeaters which act as final power amplifiers.

When a subscriber dials a number, the number is recorded on relays in the sending mechanism, where it remains stored until the operator who is to complete the call is free to do so. She then pushes a button and the relays in which the number is stored actuate other relays and cut in the proper films in the correct sequence to announce to the operator at the manual board the number which has been dialed.

Development work on this machine has been completed and numerous tests have been made of its performance. It is expected that a number of them will be placed in service before the end of the year.

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Simplified method of

Measuring broadcast harmonics

By E. C. MILLER*

A BROADCASTING station to be as effective as possible must transmit into the ether as much power as possible on its fundamental carrier frequency and as little as possible on any of the harmonics of this frequency. In considering this radiation of harmonics from a broadcast transmitter, cognizance must be taken of their relative strength. A five kilowatt transmitter can produce a field strength of 100,000 microvolts per meter at a distance of from four to five miles over flat unobstructed terrain. If the harmonic percentage radiated is 0.2 per cent, a field strength of 200 microvolts per meter is laid down for the harmonic at the same distance. In many sections of the country, signals of this magnitude are the maximum available.

Within an area of about three miles of such a station, a strong harmonic signal can be expected to harass reception. At night these intensity ranges are greatly extended, causing comparatively strong signals capable of producing cross-talk and heterodyne interference with distance stations whose signals are of comparable magnitude. Such interference is of course caused by harmonics of stations operating in the channels between 550 kilocycles and 750 kilocycles, and 1,100 and 1,500 kilocycles. However it is also well to consider the reduction of the second harmonic of the latter group. The third and succeeding harmonics of broadcast transmitters may, due to their successively weaker generation be neglected. Notwithstanding the high percentage of modulation usually obtained in present transmitters, the trend toward powers of the order of 50 and 100 kw. presents a serious problem in the adequate reduction of harmonics. Probably for powers of this magnitude a reduction of the second harmonic to 0.01 per cent is essential, but for the average transmitter a value of 0.05 per cent is sufficient. It is the purpose of this article to describe a simple method of measuring harmonic percentages in a transmitter or r.f. oscillator.

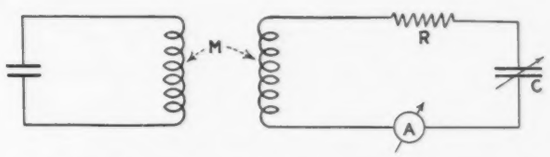

Fig. 1—Wavemeter circuit for harmonic measurement of broadcast stations

Determination of harmonic output

While the determination of harmonic percentages of broadcast transmitters is probably best effected by the use of field strength measurements at a distance from them, such equipment and facilities are not always available, so that the subject is likely in some instances to be neglected.

An ordinary selective wavemeter may be employed for the detection. A knowledge of its constants permits the calculation of the percentage of the harmonic current to that of the fundamental in the tank and antenna circuits of the transmitter or in the tuned plate circuit of an r.f. oscillator. A wavemeter coupled as shown in Fig. 1 to an r.f. generating circuit containing harmonics will reveal a current versus frequency characteristic as shown in Fig. 2. The current curve of gradual slope is that due to the fundamental, while the current humps are produced by the various harmonics, whose numbers are multiples of the fundamental frequency. The fundamental current in the wavemeter is with sufficient accuracy the mean of the two cut-off currents, while the harmonic current in the wavemeter is the difference between the maximum current at the harmonic, and the fundamental current. The numerical ratio obtained directly by these measurements is not the actual ratio of fundamental to harmonic existing in the primary, or generating circuit, but by taking into account the coupling and tuning conditions the ratio of primary or generating currents of harmonic and fundamental frequencies is equivalent to the ratio of secondary or wavemeter currents of fundamental and harmonic frequencies, and from this ratio the percentage of harmonic to fundamental may be readily determined.

Considering the case of inductively coupled circuits

Calculation of Harmonic Percentage

POWER AMPLIFIER TANK

		Wavemeter Currents										
n	Freq. K.C.	Low-Freq. Cut-Off, ma.	High-Freq. Cut-Off, ma.	I' ma.	Max. Cur. ma.	I'n ma.	Rn Ohms	$n(n^2-1)$	ωL Ohms	$\frac{In}{I}$	Per Cent Harmonic $100\times\frac{In}{I}$
2	1100.	48	46	47	86	39	15.5	6.	629.	.0033	.33

ANTENNA CIRCUIT

		Wavemeter Currents										
n	Freq. K.C.	Low-Freq. Cut-Off, ma.	High-Freq. Cut-Off, ma.	I' ma.	Max. Cur. ma.	I'n ma.	Rn Ohms	$n(n^2-1)$	ωL Ohms	$\frac{In}{I}$	Per Cent Harmonic $100\times\frac{In}{I}$
2	1100.	74	72	73	103	30	15.5	6.	629.	.00168	.168

*Assistant engineer, Buffalo Broadcasting Corporation.

as in Fig. 1 it is found that when the secondary circuit resonates at the harmonic:

$$I' = \frac{I\omega M}{\left(\omega L - \frac{1}{\omega C}\right)} \quad (1)$$

and

$$I'_n = \frac{I_n \omega_n M}{R_n} \quad (2)$$

where I' and I'_n = secondary currents of fundamental and harmonic frequency respectively.
n = harmonic number.
M = mutual inductance between primary and secondary.
R_n = secondary or wavemeter resistance at harmonic n.

Taking the ratio of these expressions and solving for the primary current ratio:

$$\frac{I_n}{I} = \frac{I_n}{I'} \times \frac{\omega}{\omega_n} \times \frac{R_n}{\left(\omega L - \frac{1}{\omega C}\right)} \quad (3)$$

When the secondary is tuned to the harmonic, $\omega_n L = \frac{1}{\omega_n C}$. Remembering that $\omega_n = n\omega$, eq. (3) reduces to

$$\frac{I_n}{I} = -\frac{I'_n}{I'} \times \frac{R_n}{\omega L} \times \frac{1}{n(n^2 - 1)} \quad (4)$$

The measurements and calculations may readily be tabulated on a form similar to that given in the table. The figures given are actual measurements on a 1,000-watt transmitter operating on 550 kc. before steps were taken to reduce the harmonics. The measurements were taken in the power amplifier tank and in the antenna circuit.

It must not be forgotten that if the indicating meter is a current-squared instrument, the square root of the readings ratio is to be substituted for I'_n/I' in eq. (4). It is to be noted that the wavemeter should remain at fixed coupling with respect to the primary for all readings at any one harmonic, but may be moved closer for measurements at other harmonics if necessary to obtain sufficient meter deflections. The measurement of harmonics by means of the above method has been made in several broadcast transmitters and oscillators, and has been found convenient in determining the effectiveness of harmonic suppression schemes.

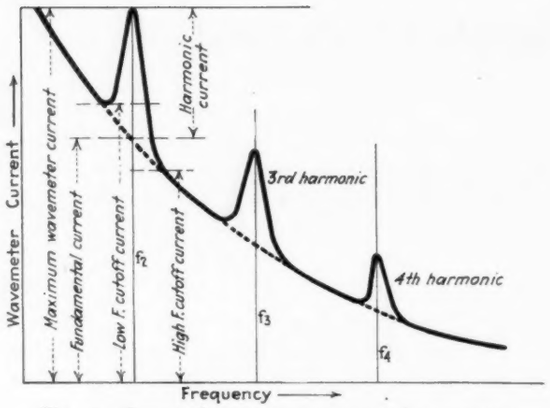

Fig. 2—Current-frequency response of wavemeter to transmitted wave

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NEW BOOKS ON ELECTRONIC SUBJECTS

Recording sound for motion pictures

Comprising 25 special papers covering the fundamentals of sound recording. McGraw-Hill Book Company. Profusely illustrated. Price $4. Published this Autumn.

THIS VOLUME represents the combined papers of 25 leading authorities in the sound picture industry. It is the outgrowth of a special course on fundamentals of sound recording and technique as given under the supervision of the Academy of Motion Picture Arts and Sciences, Hollywood, Calif. The contents include an introduction by William C. De Mille, president of the academy, and 25 chapters covering the following general subjects: Sound recording equipment, the film record, studio acoustics and technique; and sound reproduction.

The appendix includes a very complete glossary of technical terms which answer every possible question covering the technique of motion pictures. The glossary alone is a small dictionary, and worth the price of the book. All chapters are profusely illustrated, with circuit diagrams and photographs of special sound equipment.

"Recording Sound for Motion Pictures" should be the official reference and instruction book in the library of all technicians in the various branches of motion picture production, projectionists, exhibitors and engineers in the electrical and related professions.

✦

An introduction to the study of wave mechanics

By Louis De Broglie, D.Sc., Paris, translated by H. T. Flint, D.Sc.; E. P. Dutton & Co., New York. 246 pages. Price $4.25.

THIS VOLUME SHOULD clarify in the mind of the advanced student of physics the various theories proposed in explanation of the newer puzzles of wave mechanics. Price De Broglie, winner of the Nobel prize for Physics in 1929, has outlined the mathematical development of most of these theories and has indicated at what points the conceptions are no longer satisfactory. He discusses clearly and in sufficient detail the theory of Jacobi, the conceptions underlying wave mechanics, the equations of propagation of the wave associated with a particle, the principle of interference, the diffraction of electrons by crystals and the scattering of charged particles by a fixed charge, the theory of Bohr and Heisnberg, the propagation of waves, the stability of quantised motion from the point of view of wave mechanics, the meaning of the waves of quantised systems, etc.

The author appears to favor the conception of Bohr and Heisenberg, which holds that the wave does not represent a physical phenomenon taking place in a region of space; rather it is simply a symbolic representation of what we know about the particle. In summing up, he says: "The physical interpretation of the new mechanics remains an extremely difficult question. Nevertheless, one great fact is now well established: this is that for matter and for radiation the dualism of waves and particles must be admitted, and that the distribution of the particles in space can only be foreseen by the consideration of waves. Unfortunately the profound nature of the two members in this duality and the precise relation existing between them still remain a mystery."

Output transformer design—Part II

By R. C. HITCHCOCK and W. O. OSBON*

IN THE first part of this article (November *Electronics*) the general aspect of transformer design was discussed, the mathematics of transformer usage was given and the general groundwork laid for actual design which is discussed in this article.

In Fig. 1 is an alignment chart giving the relationship between f_o, R_p, and L_p based upon the ratio $\omega L_p/R_p = 1$ as discussed in Part 1. Let us now consider a typical case, where the primary must carry steady plate current as it usually does. Under this condition the design of the transformer is a simple matter since a direct method has been developed by C. R. Hanna for calculating choke coils and transformers which carry direct current. The design curves shown in Fig. 2 for 4 per cent silicon steel and for hipernik (50 per cent nickel and 50 per cent iron), respectively, are taken from his paper.[1] In these curves the notation is as follows:

L = inductance of coil in henries.
I = direct current in amperes.
V = volume of iron core in cm.^{3}
N = number of turns.
l = mean length of magnetic circuit in cm.
a = length of air gap in magnetic circuit in cm.

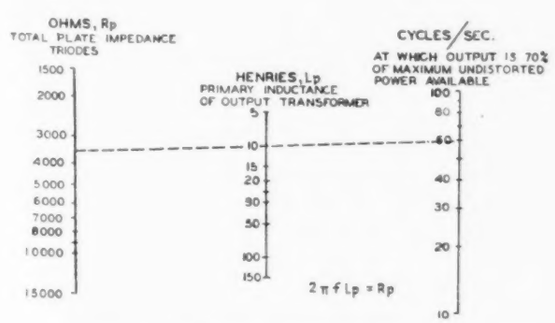

Fig. 1—Alignment chart for determining primary inductance

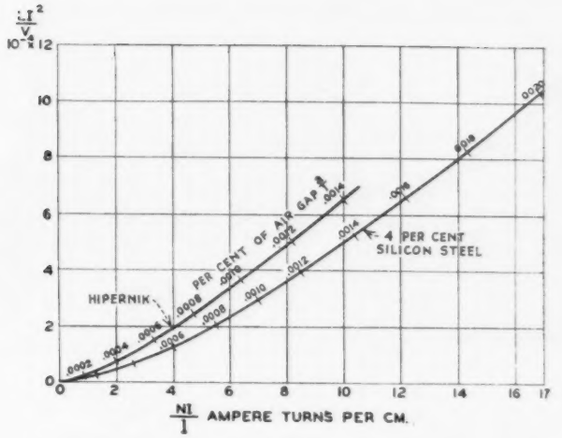

Fig. 2—Design curves for 4 per cent silicon steel and for hipernik

The value of the inductance is determined as outlined in Part 1 and the amount of the direct current is known when the output tube is decided upon, so that the quantity $\frac{LI^2}{V}$ can be found for an assumed value of core volume. The corresponding values of ampere turns per centimeter, NI/l, and per cent air gap, $\frac{a}{l}$, are read from the curve for the particular kind of iron being used. The required length of air gap to be inserted in the magnetic circuit and the number of turns are then readily determined. It may be that in order to get the required number of turns in the window of the core selected, the size of wire will have to be so small as to make the resistance of the winding excessive. If this is the case, either the volume of the core must be increased by stacking the punchings higher or punchings with a larger window must be used. If the volume or mean length of core are changed, it will be necessary to go through the calculations for N and a again.

When the transformer is to work out of a push-pull stage, it is customary to assume 10 per cent unbalance in the plate currents of the two tubes. For example, with a UX-250 push-pull stage, a difference in plate current of 0.0055 amperes would be assumed for the two tubes. This current flows through only half of the winding, which is equivalent to 0.0027 amperes through the total winding. The value of current to be used in calculating the number of turns is, therefore, 0.0027 amperes.

Several writers[2,3] have worked out design curves similar to Mr. Hanna's for other kinds of core material.

In the arrangement using a combination of output choke and transformer, there is no direct current in the transformer primary. The calculation of a coil under such conditions is not as easy a matter as one might think. The formula for the inductance is simple enough, being merely—

$$L = \frac{0.4\pi N^2 A\mu}{l}$$

The question which arises is, of course, the value to use for the permeability μ. The permeability is affected by a number of factors, such as the magnitude of the

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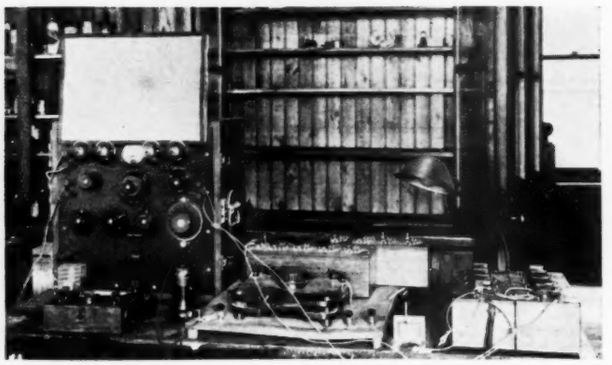


Transformer testing equipment used by author

signal current flowing through the winding, the amount of handling and bending the iron has received, and its previous magnetic history. A fourth important factor is that unless the core is made up of ring punchings instead of E or L punchings with lap joints, there will always be a small air gap in the magnetic circuit which will affect the apparent permeability of the iron. None of these factors are definite, so that the permeability and hence the inductance, are also indefinite quantities.

These factors also affect the permeability in a transformer which is carrying direct current, but where an

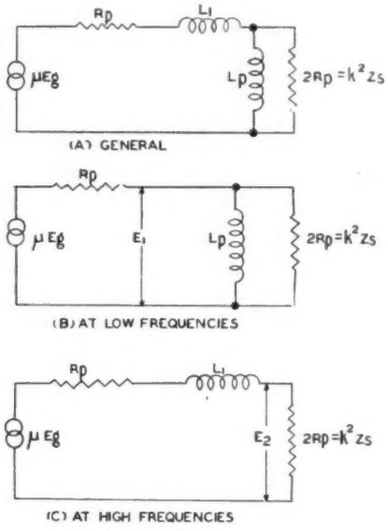


Fig. 3—Equivalent circuit of output stage

appreciable gap is purposely inserted in the magnetic circuit, and where there is a relatively large and definite value of steady magnetization, the effect is not nearly so pronounced.

It has been the experience of the writers that, under conditions ordinarily met with in practice, the inductance of a transformer primary when it is carrying a small amount of direct current does not differ greatly from the inductance when there is no direct current. Under conditions where the difference is appreciable it is always to the advantage of the coil without direct current. A paper by Prof. H. M. Turner[4] presents some excellent data confirming these statements.

In view of the above it has been customary with the authors, when designing transformers which do not carry direct current, to assume that there is a small amount of direct current flowing through the winding. The procedure is then the same as has already been outlined. For ordinary output transformers a current of 3 to 5 milliamperes is suitable.

Effect of leakage inductance

At high frequencies ωL_p becomes large compared to $2R_p$, so that the equivalent circuit of Fig. 3-A reduces to that shown in Fig. 3-C. The voltage drop across the load at high frequencies is—

$$E_2 = \frac{2R_p \mu E_g}{3R_p + J\omega L_1} = \frac{2R_p \mu E_g}{\sqrt{9R_p^2 + (\omega L_1)^2}} \quad \text{(1)}$$

At low frequencies $(\omega L_1)^2$ becomes negligible compared to $9R_p^2$, and E_2 attains its maximum value, $E_m = 2/3\mu E_g$. The voltage across the load expressed as a percentage of the maximum is, therefore—

$$\frac{E_2}{E_m} = \frac{1}{\sqrt{1 + \frac{1}{9}\left\{\frac{\omega L_1}{R_p}\right\}^2}} \quad \text{(2)}$$

Here again the power is proportional to the square of the voltage, so that the percentage of maximum undistorted power delivered to the load is given by—

$$\frac{P_2}{P_m} = \left\{\frac{E_2}{E_m}\right\}^2 = \frac{1}{1 + \frac{1}{9}\left\{\frac{\omega L_1}{R_p}\right\}^2} \quad \text{(3)}$$

Formulas (2) and (3) are represented graphically by Curves 1 and 2 of Fig. 4 respectively.

Fig. 5 shows the calculated curves for two typical output transformers. Transformer No. 1 was for a push-pull circuit and its leakage inductance was 0.152 henries. Its response is quite satisfactory. Transformer No. 2 was for a single tube and its leakage inductance was 0.288 henries. The low R_p out of which it works and the high value of L_1 combine to make its response at high frequencies very poor. On the other hand, this poor response may have been intentional, for this particular transformer is used with a loud speaker which has a prominent peak in its response at high frequencies.

Leakage inductance

Fig. 6 shows a section through a typical output transformer. E. G. Reed in his book, "Essentials of Transformer Practice,"[5] has developed an approximate formula for the leakage reactance of a transformer which, when modified to suit our needs, takes the form—

$$L_1 = 1.05 \times 10^{-6} \frac{N^2}{l}\left(3l_g g + l_p d_1 + l_s d_2\right) \quad \text{(4)}$$

where:

L_1 = leakage inductance referred to the primary in henries.
N = primary turns.
l = length of leakage path in inches. (See Fig. 5).
l_g = mean length of layer of insulation between windings, inches.
l_p = mean length of primary turns, inches.
l_s = mean length of secondary turns, inches.
g = thickness of insulation, inches.
d_1 = depth of primary winding, inches.
d_2 = depth of secondary winding, inches.

It will be noted that the terms $l_g g$, $l_p d_1$ and $l_s d_2$ are respectively the cross-sectional areas in a plane perpen-

dicular to the coil axis of the insulation, the primary winding and the secondary winding. Values of leakage inductance calculated with this formula agree satisfactorily with actual measured values.

The value of this formula lies in its usefulness in checking a transformer design to see if its high-frequency response will be satisfactory. If the designer of transformer No. 2 in Fig. 5 had used the formula, he would have observed that this leakage inductance was high and could have taken steps to lower it, had he thought it desirable. Assuming that the thickness of insulation was fixed, there are two ways he could have done this. First he could have split one of the windings into two sections and interleaved the other winding between them. Or, he could have reduced the number of primary turns and then compensate the decrease in primary inductance by using a larger core.

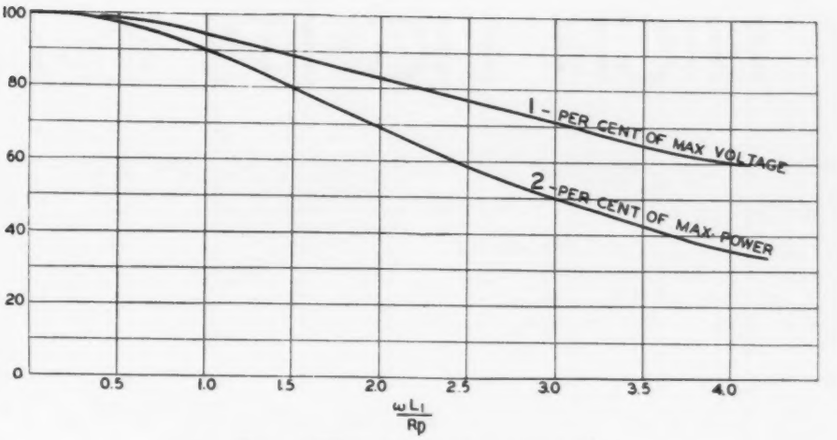


Fig. 4—Effect of leakage reactance of an output transformer

For example, from Fig. 4 we see that to get 70 per cent of the maximum power requires that $\omega L_1/R_p = 2$. If we are satisfied with 70 per cent at 5,000 cycles, the leakage inductance may be no more than—

$$L_1 = \frac{2 \times 1{,}800}{6.28 \times 5{,}000} = 0.115 \text{ henries.}$$

Equation 4 shows that L_1 varies as the square of the number of turns, so that in order to reduce L_1 from 0.288 to 0.115 henries it is necessary to decrease the number of turns by a factor $\sqrt{\frac{0.288}{0.115}} = 1.58$. The primary inductance is reduced in the same ratio as the leakage inductance, and the primary inductance varies only as the first power of the core area, so that it is necessary to increase the core area by $(1.58)^2$ or 2.5 times in order to retain the same value of primary inductance.

The information presented in the foregoing paragraphs, although specifically applicable to the output transformer, may also be applied to other forms of coupling devices. For instance, the same considerations as to ratio and primary inductance apply as well to the design of an output choke as to a transformer. If the choke is not tapped, however, it is an auto-transformer of 1:1 ratio, so that its primary and secondary windings are identical and occupy the same space. There is then, no leakage flux between the two windings and the leakage inductance is zero. In the case of the tapped choke there will be a leakage flux between the primary and secondary, but the formula for calculating the leakage inductance given above will not apply in this case.

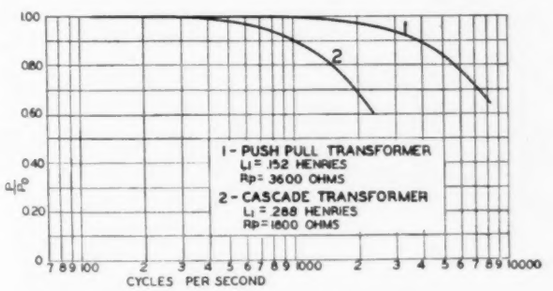


Fig. 5—Effect of leakage inductance on power output for two typical transformers

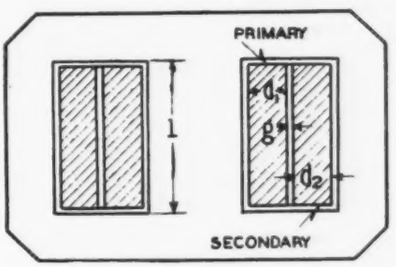


Fig. 6—Section through typical output transformer

Another formula must be developed using the same method as was used in the text referred to previously.[5]

When an output choke and condenser are used in combination with a transformer, the inductance of the choke, with the plate current flowing through it, should be at least as great as the primary inductance. The blocking condenser in such a circuit must be large enough so that its reactance at the lowest frequency it is desired to reproduce is low compared to the primary equivalent of the loud speaker impedance.

This type of output circuit has a very distinct advantage over the one using an output transformer alone. It is generally used with a single output tube where the direct plate current is considerable. By shunting this plate current through the choke coil, the number of primary turns necessary to give a suitable value of primary inductance is considerably lower than it would be if the relatively large plate current were required to flow through the primary winding. Since the leakage inductance is directly proportional to the square of the primary turns, this will result in an appreciable reduction in the effect of the leakage reactance.

[1]C. R. Hanna, "The Design of Reactances and Transformers Which Carry Direct Current." *Jour. A.I.E.E.*, 46, 108; Feb., 1927.
[2]A. A. Symonds, "Loop Permeability in Iron and the Optimum Air Gap in an Iron-Core Choke with D.C. Excitation," *Experimental Wireless and the Wireless Engineer*, vol. 485, September, 1928.
[3]D. E. Replogle, "Notes on the Design of Iron-Core Reactances Which Carry Direct Currents," *QST*, XII, 23; April, 1928. Also "Additional Notes on Iron-Core Reactances," *QST*, XII, 46; August, 1928.
[4]H. M. Turner, "Inductance as Affected by the Initial Magnetic State, Air Gap, and Superposed Currents," *Proceedings I.R.E.*, Vol. 17, No. 10, October, 1929.
[5]E. G. Reed, "Essentials of Transformer Practice," Second Edition, pp. 117-120; D. Van Nostrand, Inc., 1927.

HIGH LIGHTS ON ELECTRONIC D

Electric eye separates chemicals

Many chemical analyses, basic processes in every industry, depend upon the detection of color changes. The more elementary among these are the shade variations of "indicators" used to show whether a solution is alkaline or acid or when these two chemical conditions neutralize each other.

"As we all know," says Walter Krahl, chief engineer with the Arcturus Radio Tube Company, Newark, N. J., "the sensitivity of the human eye to color changes varies with the individual. Some of us are color blind. Such persons are unable to discriminate among delicate color changes. To a mild case of color blindness, pink and yellow appear the same color, and so do blue and green. A bad case of color blindness sees photographically — that is, everything appears like a photograph, in varying shades of black and white. Many people are color blind without knowing it, and often hold down positions where a certain degree of color discrimination is desirable or even necessary.

"An artificial eye however, employing the photo-electric cell, can be designed that is sensitive to color changes the normal eye cannot detect. Automatic mixing machinery can be designed for industrial chemical plants, in which the flow of different chemicals will be automatically stopped when an acid or alkaline neutralization is achieved, the neutral point being instantly noted by the photo-electric cell, and the associated apparatus made to control or stop the addition of the neutralizing agent."

"In the final analysis," concludes Mr. Krahl, "this may mean anything from a cheaper toothpaste to a better soap!"

Unique animated chart controlled by photo-cells

Photo-electric cells control a striking demonstration of the effect of voltage changes upon the wattage, candle power, and cost of electric lamps in an ingenious animated chart on exhibition at the Westinghouse Lighting Institute in Grand Central Palace, New York City. The animated chart consists of five illuminated columns, under the headings of voltage, wattage, candle power, total cost, and cost per candle power. Ordinates are in percentage of normal. As the height of the column headed percentage of normal voltage is increased above the 100 per cent mark, all the columns of light are lengthened but in varying proportions to correspond with the actual variation in these factors with the voltage. The height of these columns is controlled merely by placing the hand between a light source and one of two photo-electric units located at the side of the chart.

The movement of each of the columns is accomplished by an individual shutter which moves before a vertical row of ten-watt lamps in a box behind each column. The shutters are operated by cams of different sizes on a common cam shaft rotated through reduction gears by a small electric motor. The action of the photo-cells is merely to start, reverse, or stop the motor in a simple and striking way. This is accomplished as shown in the accompanying circuit diagram.

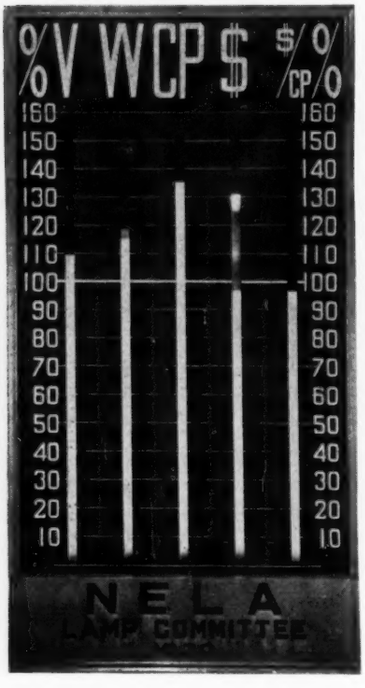
In two of the columns a portion of the column length is colored to show additional information. The colored portion of these columns is produced by inserting colored translucent material in the shutter mechanism. In the "watts" column the red represents the watts due to losses in the wiring, and in the "cost" column a red and a green portion represents the fixed charges and the cost of lamp renewals. These colored films or screens are associated with the shutters but driven by separate cams and gears at their own proper speed.

This chart was designed by G. S. Merrill of the National Lamp Works, for the N.E.L.A. Lamp Committee. It was first exhibited in the Lamp Committee's booth at the last N.E.L.A. convention at San Francisco, its purpose being to demonstrate the effect of voltage variations in industrial lighting.

Ultraviolet light shows up check raiser's changes

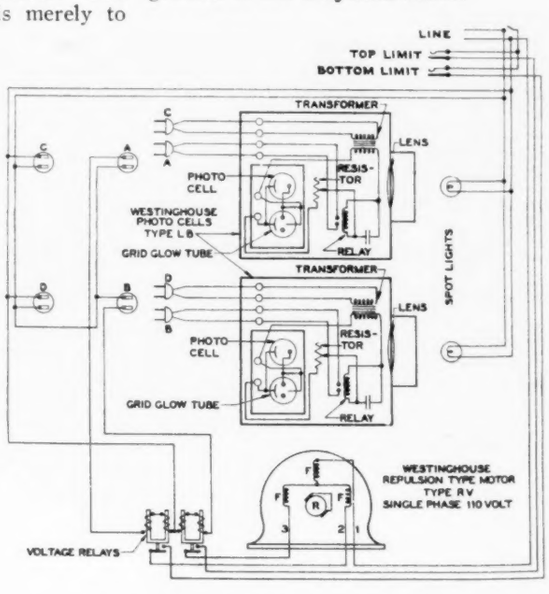
The treatment of check paper with aesculin, a white powder obtained from the bark of the horsechestnut tree, makes it possible for the bank teller to detect with ease erasures and changes which otherwise might escape notice.

Aesculin fluoresces, or glows, when placed under ultraviolet light. An erasure on paper treated with this substance would show up as a dark spot on an otherwise luminous surface. A patent on the process has just been granted to Dr. D. Julian Block.

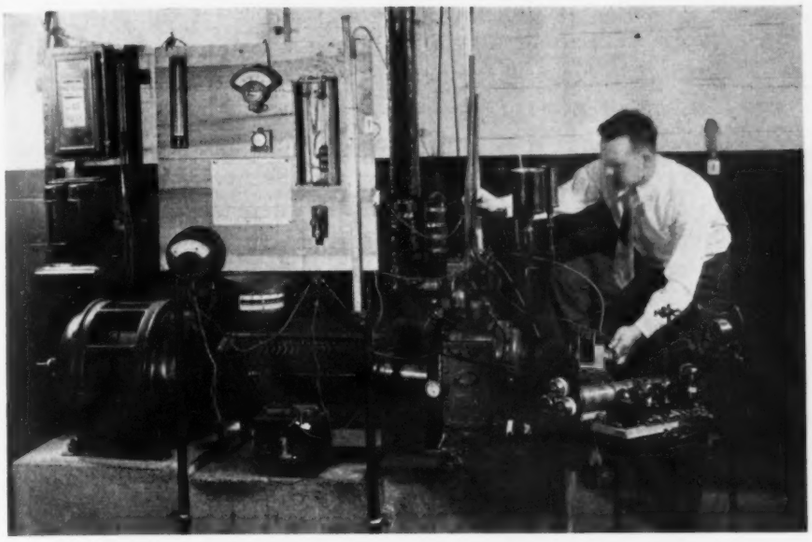


The moving columns on this chart bear fixed relations to each other, and their movement for various "lamp-voltage" values is controlled up or down by intercepting with the hand, one of two photo-cells, through the circuits at right.

Such mechanism has, of course, many other applications in industry.



DEVICES IN INDUSTRY + +



Normal engine noises are screened out by "high pass" filters, allowing only the knock, which has a frequency of 3,000 cycles per second, to pass through the vacuum tubes

+ + +

Tube device controls gasoline "knocks"

Electronic science has entered a new field and is now controlling anti-knock qualities in gasoline.

Microphone and vacuum tubes, magnifying sounds a hundred-fold, have been combined with other delicate instruments to form an electrical ear to detect the faintest whisper of a knock and yet to remain deaf to other engine noises!

The apparatus, sensitive to sounds far beyond the range of the human ear, was developed by scientists of the Atlantic Refining Company, according to Dr. T. G. Delbridge, head of the company's research laboratories. It was designed in the course of research leading to a new type of gasoline, perfected after years of study and an expenditure of more than a half million dollars. Necessity for the device arose when scientists were able to find none capable of interpreting engine noises, or delicate enough for their purpose.

In operation, the "mike" is suspended from coiled springs near the engine testing the gasoline. Sounds that could not be heard by man are picked up by the microphone, and the rest of the apparatus then selects and magnifies the knock and registers the sound intensity.

Use singing wire to measure twist of shaft

A singing piano wire used to measure the tiny twist which the great engines of an ocean liner give to the great steel rod that forms the propeller shaft is a new application of the science of electronics perfected recently in Germany and given in first practical test on the shafts of the steamship *Bremen*.

No metal ever is absolutely rigid. Although the great propeller shafts of such giant liners are made amply strong to carry the gigantic horsepower of the engines without twisting apart, such shafts do twist a small fraction of an inch under their load of engines and screw. Engineers need to measure such twists accurately, not only to detect any unsuspected weakness of the metal which might make trouble later on but also to help improve designs and specifications for future shafts and engines. In the new method of measuring this tiny, twist, far too small to be seen while the shaft is rotating, a piece of steel piano wire is stretched between projections on two collars clamped to the shaft some feet apart. If the shaft between these collars twists by even a hundredth of an inch the distance between the two projections increases a trifle and the piano wire is stretched. This changes the pitch of the musical tone which the wire gives out, just as a piano tuner changes the tone of a string in that instrument by stretching it more or less. The single piano wire fastened to the shaft is kept singing by an electric device and the tone which it emits is compared with that from a similar wire stretched to a known degree. Any twist of the shaft is thus measured.

+ + +

CAN COMPARE WIDELY SEPARATED COLOR SAMPLES

The new color comparator designed by Dr. H. H. Sheldon of New York University, New York City, enables dyers to compare tints with an accuracy impossible to the eye. Used under the artificial light of winter afternoons, when the peak of textile manufacture comes, it greatly increases the productive hours of the dye-room. Samples compared can be in differnt rooms

electronics

McGraw-Hill Publishing Company, Inc.
Tenth Avenue at 36th Street
New York City

O. H. CALDWELL, *Editor*

Volume 1 — DECEMBER, 1930 — Number 9

The press, radio and sound-pictures to the rescue

THE three greatest forces available for overcoming the present economic depression in the shortest time comprise the press, radio and sound pictures. Through these agencies every person in this country can be informed daily and even hourly of improvements in trade progress. It is interesting to note that two of these mediums are basically electronic. Past depressions did not have their assistance for the come-back. The electron tube has already served mankind well—it stands ready today to carry the glad tidings of progress to the four corners of the globe.

Such forces alone cannot cure the business ills of the nation but they are already alleviating the pain by the entertainment offered the public. Motion-picture producers are planning record expenditures for 1931. Radio broadcasters stand ready to spend millions if granted high power. And, indication of the optimism of the press, the McGraw-Hill Company has contracted for a new $7,000,000 building now being erected.

The bottle-neck

"MUSIC put on the air," says Leopold Stokowski, conductor of the Philadelphia Symphony Orchestra, "is compressed until it is out of shape, because radio can carry only a certain amount of energy."

The celebrated conductor whose orchestra is heard via radio through the courtesy of Philco is partly correct and partly not. A full orchestra has an output range of volume of about one million to one (60 db). Telephone lines connecting pick-up with transmitter can handle only about 30 db. Here is a two-to-one compression in volume before the radio program really gets started.

When the pianissimo passages of the orchestra threaten to be lost in line noise, the pick-up operator must artificially increase the sound level; when the fortissimo passages threaten to cross-talk into adjacent wire circuits, the operator must reduce these peaks of power which give vigor to the rendition.

The radio is not at fault; it is the wire circuits. No amount of engineering to eliminate frequency distortion at transmitter or receiver can eliminate amplitude compression. No satisfactory method of combating this inherent distortion has been put into practice.

Electronics—a wide field

RADIO engineers frequently claim that their profession calls for a greater knowledge of physics and chemistry than that of the electrical engineer.

It is probable that the electronic engineer of the future will be even better equipped. The application of a photo cell to industry demands more than a knowledge of electron emission. It involves such deep and, to most engineers, closed subjects as the quantum theory, and realms of physics and chemistry quite often hurried through by men on their way to the brighter—and more crowded fields of communication or power.

Optics plus photo cells have made possible the recording of sound on motion picture film. Television awaits some optical, mechanical, or electrical genius who will get around the scanning disk.

All new industries attract to them poorly equipped consultants who are willing to acquire their knowledge at the expense of their early clients. It is to be hoped that the industry to be built up around the adaptation of photo cells and vacuum tubes to other services than radio or sound pictures will be in the hands of engineers of the widest possible training and experience.

Speeding up the fireman!

AN enterprising team of dealers and servicemen in a middle western city have applied electron tubes and associated apparatus in an interesting manner. In this city a number of outlying fire departments are in communication over private wires with a central bureau. At this central desk someone is always on duty. To get the district apparatus into action the central bureau telephoned to the other offices.

The new system consisted in putting a microphone on the chief's desk, a power amplifier and loud speaker in each station house. Now the chief talks to all the stations at once and in such stentorian tones that in the middle of the night, firemen can get their orders on their way down the slippery pole from the sleeping room.

In a test those districts equipped with loud speakers instead of the older system got under way and arrived at the fire sooner than the others not so equipped.

Sound-movies for the deaf

A LEADING authority of the American Acoustical Society tells us that approximately 10 per cent of our population or 12,000,000 people in the United States, suffer from defective hearing in one degree or another. With the change-over from silent to sound moving pictures, thousands of such people have been cut off from the one form of entertainment they enjoyed most.

Means are now available to equip theaters with individual ear phones so that such persons can still enjoy the movies with the addition of sound. Usually from 20 to 50 seats equipped with ear phones, depending upon the size of the theater, would take care of this 10 per cent. The return to the theater management in a short time would pay for such equipment, besides building up good will in the community.

"Electronic knife" third great advance in brain surgery

THE application of electro-surgery to surgery of the brain and nervous system marks the third great advance that has been made in the field of neuro-surgery, according to Dr. Ernest Sachs, of St. Louis, speaking before the American College of Surgeons at Philadelphia, last month.

By means of the "radio knife" brain tumors that were formerly considered inoperable can now be dealt with, and other types of brain tumors can be removed more safely than before.

The technique of the method takes time to learn, but Dr. Sachs prophesied that more and more will be accomplished with it in the future as surgeons become increasingly familiar with it and learn to realize its possibilities.

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For cumulative index of 1930 issues of Electronics, see page 446

ELECTRONICS points with some pride to pages 446, 448 and 450 of this issue where an index of its first nine issues (Volume I) will be found. A perusal of this summary of editorial material will make clear to the curious reader the *raison d'être* of *Electronics*—to bring to the engineers who design and manufacturers who build electronic apparatus (radio, sound pictures, industrial applications of tubes as well as electronic tubes themselves) the advances in their art and the news of their industry.

Such an index in a new art like electronics provides a unique and invaluable history of pioneer work, a fascinating disclosure of the wide application of electronic tubes to industrial problems, and a source of technical and manufacturing information on specific subjects.

LETTERS TO THE EDITORS

E-lectron-ics—the wedding of the sciences!

Editor, ELECTRONICS:

I was very much interested in your recent editorial regarding the typography of Electronics, entitled "That little 'e'; its big significance."

Electron comes from a Greek word which is usually translated "amber." If the first "e" is omitted, we have the Greek word "lectron," which means "bed." In the plural the word means "marriage bed." So that first little "e" is rather significant.

I always make it a point in my classes that the word electron be always pronounced "e-lectron," so as not to offend classical students and purists. I think that the point is rather well taken.

WALTER J. SEELEY,
Professor of Electrical Engineering.
Duke University, Durham, N. C.

▼

An astronomer comments on the photo-cell

Editor, ELECTRONICS:

The photo-electric cell has not been very widely used in astronomy, partly due to its erratic nature. For about fifteen years, however, a photo-electric cell photometer has been used with success by Professor Joel Stebbins of the Washburn Observatory, Madison, Wis. Photo-electric photometers are also used in Babelsberg Observatory, Berlin, and three or four others have been made for different observatories. One has just been made by Stebbins for the Yerkes Observatory.

But nearly always photo-cells are unsuccessful because of "dark currents," instability of the cells, and too great sensitiveness for the irregularities of our atmosphere. Stebbins has used his instrument to get some of the most accurate light curves of variable stars there are on record, but it has taken a lifetime of technical work to develop the photometer and use it with moderate success.

We keep saying to ourselves that some day the photo-electric photometer will be simple and practical.

HARLOW SHAPLEY,
Harvard College Observatory,
Cambridge, Mass.

▼

Blind in need of 600 radio sets

Editor, ELECTRONICS:

The American Foundation for the Blind has, during the past two or three years, dstributed several thousand completely equipped radios throughout the country to needy blind people who had not the means to secure these for themselves.

We have on file hundreds of letters, telling of the great boon that this has conferred upon them, and of the inestimable blessing that these radios have brought to their lives, otherwise spent in monotonous darkness.

Mr. Powel Crosley some time ago was good enough to donate to us one thousand sets for this purpose — Mr. Atwater Kent kindly sold us at a nominal price two hundred and fifty obsolete models, which we also distributed among our needy blind friends throughout the country.

We now have applications from approximately six hundred more needy blind people, to whom a radio would be a gift from Heaven, but who are unable to procure such sets.

I am wondering whether you could possibly help us enlist the interest of some manufacturer or manufacturers who might have a quantity of obsolete models that they would be willing to let us have for this purpose—or possibly sell us at a nominal price; they need not be an expensive type, in fact the cheapest kind would do, so long as they are efficient.

Mr. William Ziegler, Jr., and I personally will donate most of the money to cover the above expense, if the radios are not available as a gift.

M. C. MIGEL,
President American Foundation for the Blind,
125 E. 46th St., New York City.

▼

Chicago's future "Hall of Electronics"

Editor, ELECTRONICS:

I want to express my appreciation of your recent news item concerning our Hall of Electronics in the new Museum of Science and Industry, now being completed in Jackson Park, Chicago.

We are setting aside several thousand square feet for the development of the electron theory and the engineering and industrial applications of the electron tube.

This was the idea of your magazine, and you deserve the fullest credit for it. I think we shall be the first museum in the world which will pay adequate attention to the subject of electronics in this manner.

WALDEMAR KAEMPPFERT,
Director, Museum of Science and Industry,
300 West Adams St., Chicago, Ill.

▼ ▼ ▼

Albert Coates expects new art in microphone technique

Albert Coates, noted English conductor, guest-leader of New York's Summer symphonic concerts at Lewisohn Stadium, who studied science at Liverpool University under Sir Oliver Lodge, believes that radio's microphone picks up sound waves like a person who listens with only one ear. Mr. Coates declares that he is convinced, notwithstanding the perfection claimed for present-day broadcasting, that music sent over the radio or reproduced from phonograph records a few years hence will be vastly superior—more nearly like the original sound—than engineers are able to produce at present. He believes that this will evolve through advances in the art of microphone technique, which will create a new era in music appreciation.

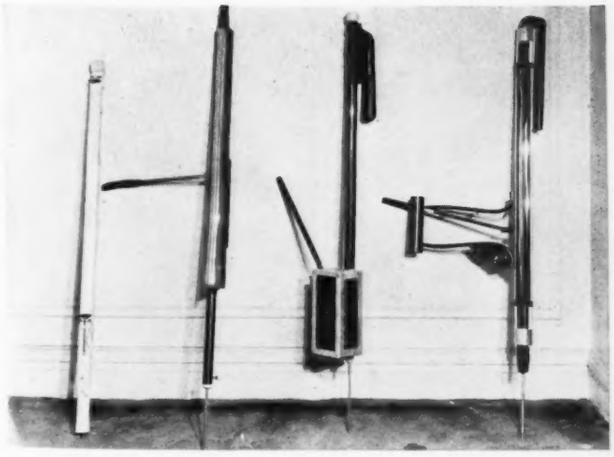
As a motion picture is given the effect of depth through a system of twin exposures and projections of a scene, the broadcasters will learn to use microphones in a way to give the effect of natural sound, which is now largely lacking in many presentations, Mr. Coates said.

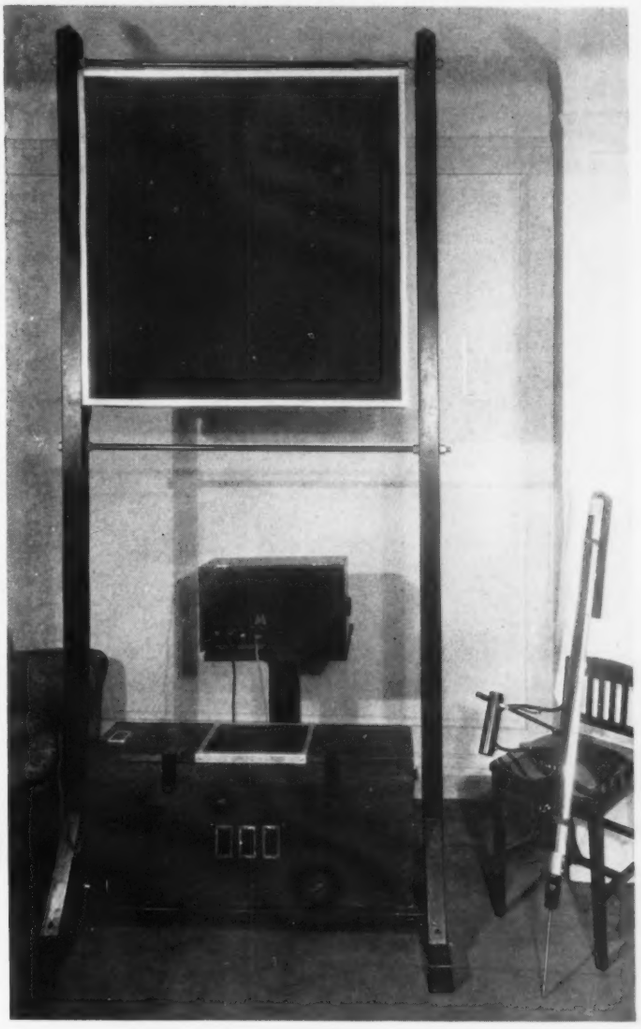
Higher altitudes better reception

The higher the altitude the better radio reception conditions become, says Federal Radio Commissioner H. A. Lafount, who draws this conclusion from his own recent experience in dialing 32 stations on a portable receiver at an elevation of 11,200 feet during a recent tour of the Rocky Mountain region. Radio, Mr. Lafount adds, is a godsend to the lonely ranchers, rangers and sheepherders of the mountains.

ELECTRONIC MUSICAL INSTRUMENTS

By combining fundamentals and overtones, electronic musical instruments make possible new timbres and qualities never before heard. Examples of such instruments are the electronic organ of M. Coupleaux of Paris, France (seen at the right), and the new keyboard form of the American theremin (illustrated below). See also *Electronics* for September, 1930, page 272

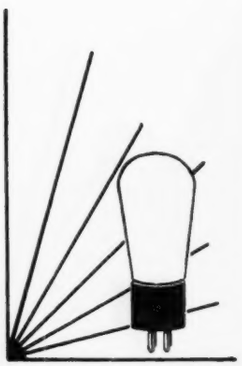




To accommodate musicians familiar with stringed instruments, these new forms of antenna control for the theremin have been developed, both with separate pick-up and with attached loudspeaker and amplifiers

Circuit Requirements

ONE of the most important sections of the RCA Radiotron Company is the circuits laboratory. Here you will find a staff of skilled engineers investigating every possible circuit requirement under which RCA Radiotrons could be called upon to operate. RCA Radiotrons are not only manufactured under most advanced methods and required to meet exacting specifications, but they are engineered for modern circuit requirements. Only the finest of electrical instruments are used to



The RCA Radiotron shielded test room is used for making sensitivity and selectivity radio-frequency tests. Shielding protects testing circuits from exterior electrical disturbances.

In the RCA Radiotron instrument laboratory all meters are checked and calibrated, at periodic intervals, against standards. Thus, absolute accuracy is insured in the testing of tubes and circuits.

RCA RADIOTRON

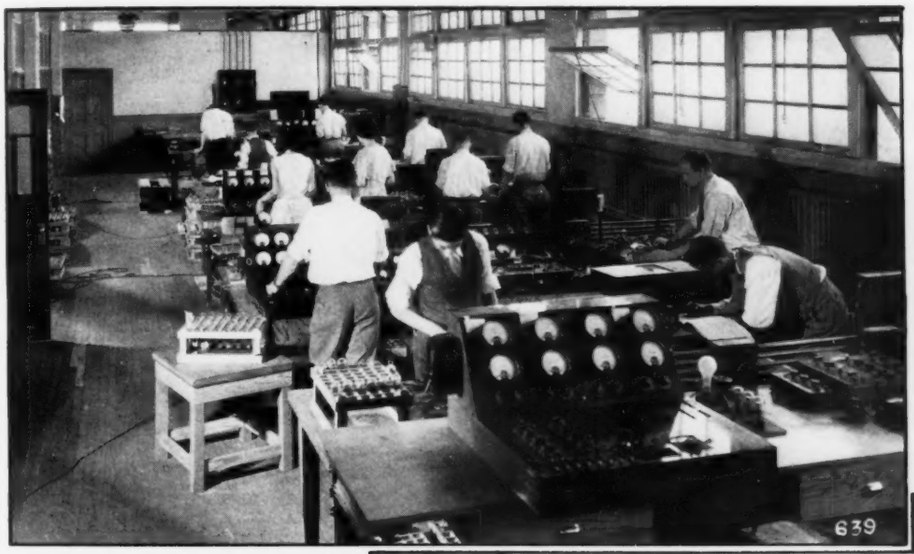
SUBSIDIARY OF RADIO

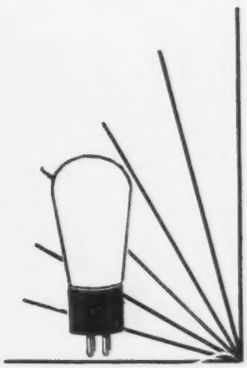
« « « HARRISON

Constantly Analyzed

make delicate electrical measurements. These testing instruments are kept accurate by the RCA Radiotron Standards Laboratory. Circuit investigations are carried on in special, shielded rooms which are absolutely free from outside electrical disturbances.

RCA Radiotrons are the standard of the radio industry because they are backed by the latest scientific knowledge known in the art of vacuum tube manufacturing.





In the RCA Radiotron general testing laboratory extensive tests are run on sample tubes for development purposes. These tube characteristic tests serve to increase the present tube efficiency.

The RCA Radiotron circuit laboratory is used for experimentation with new radio circuit designs in order to develop circuits that will best utilize the tube characteristics of RCA Radiotrons.

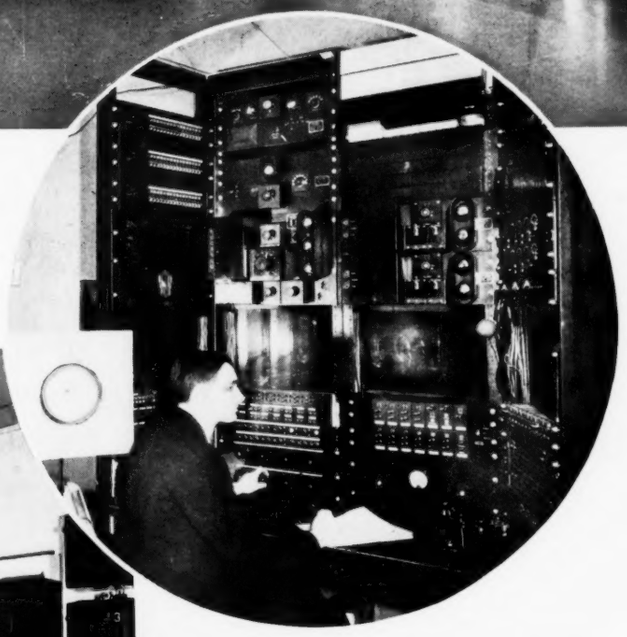
COMPANY » » INC.

CORPORATION OF AMERICA

NEW JERSEY » » »

Electrical transcriptions for broadcasting

View of the main recording studio of the Judson Radio Program Corporation, New York City. Here electrical-recorded phonograph records used in broadcasting stations are made



The monitoring room of the studio (above) where proper balancing of the various microphones and correct volume is maintained in recording

One of the disk recording machines (left) where an electrically-operated sapphire stylus transfers the sound vibrations from the amplifiers to the wax record. The suction tube seen leading from the ceiling is provided to remove the wax thread which is cut by the sapphire knife

NEWS
OF THE ELECTRON INDUSTRIES

Two new RMA directors

Two new directors elected unanimously to the RMA board at its meeting, November 18, in Cleveland, Ohio, were Eugene R. Farny of the All-American Mohawk Corporation, North Tonawanda, N. Y., and A. S. Wells of the Gulbransen Company, Chicago, Ill. They were elected to fill vacancies caused by the resignations of Lester E. Noble of Springfield, Ohio, formerly of the United Reproducers Corp., and John C. Tully of Chicago, formerly of the Bremer-Tully Company, both of whom are not now actively identified with the radio industry. Messrs. Noble and Tully served for several years in important capacities in the RMA. Mr. Noble was formerly chairman of the association's Merchandising Committee, and Mr. Tully its treasurer. The new directors are prominent and active figures in radio manufacturing.

✦

Taylor Vacuum Products & Co., Inc., 1500 N. Ogden Ave., Chicago, Ill., has been organized with the following officers: A. F. Maitland, president, W. G. Taylor, chief engineer and vice-president, and W. M. Craig, secretary, treasurer and sales manager. Mr. Taylor was formerly connected with the engineering staff of the United Air Cleaner Corporation of Chicago. Mr. Craig has been associated with the tube and radio fields for a number of years. This company is specializing in making special heavy-duty, 250, 281, 866, 845-B, and 210 tubes; in custom building of special tubes and the designing of tubes of all sorts. The general superintendent of the company is Mr. W. W. Dwyer who has had 15 years' experience in the tube field and was formerly with the Western Electric Company.

✦

Coming meetings

The American Physical Society—Annual meeting, Cleveland, Ohio, December 30-31, 1930.

Acoustical Society of America—Los Angeles, Calif., December 12-13, 1930.

American Association for the Advancement of Science—Cleveland, Ohio, December 29-Jan. 3, inclusive.

American Institute of Electrical Engineers—Winter Convention, New York City, January 19-23, 1931.

McMurdo Silver, president of Silver-Marshall, Inc., has just returned from the East where he addressed dealer meetings at Newark, New York City and Boston. He reports that public acceptance of superheterodynes has been greater than the most optimistic expectations.

Standard Transformer Corporation, 852 Blackhawk St., Chicago, Ill., has announced the appointment of Everett E. Gramer as Chief Engineer. Mr. Gramer is widely known among the users of transformers and is considered an authority on transformer design and production. He was formerly active and instrumental in the success of the Transformer Corporation of America during the period in which it made transformers exclusively. The Standard Transformer Corporation also announces the addition of approximately 5,000 square feet as added production space. This was necessitated by the substantial volume of business the company was obligated to produce.

The Ward Leonard Electric Company, Mount Vernon, N. Y., announces the appointment of R. C. James as sales representative in the Seattle district.

✦

JOHN W. MILLION, JR.

John W. Million, recently appointed chief engineer Audiola Radio Company, Chicago, Ill. He was formerly with the Brunswick-Balke-Collender Company in the same capacity and later research engineer with the Utah Radio Products Company

Mr. James' organization will be located at 2321 Second Avenue, Seattle, Washington.

W. R. G. Baker, formerly with the General Electric Company at Schenectady, N. Y., has assumed charge of manufacturing activities of the RCA-Victor Company at Camden, N. J., according to an announcement of the RCA-Victor company.

Mr. Baker, who was vice-president in charge of engineering at this plant, will have the added responsibility of production scheduling and manufacturing at the Victor company. Mr. Baker succeeds Alfred Weiland who was in charge of manufacturing for the old Victor Talking Machine Company and who continued in this capacity when the company was taken over by the Radio Corporation of America.

The Magnavox Company, with general offices at 155 East Ohio Street, Chicago, Ill., announces the opening of a factory branch in Sydney, New South Wales, Australia. The opening of this branch has been warranted by the increased demands for Magnavox dynamic speakers in Australia and New Zealand, and will now place the company in much better position to render immediate delivery to its manufacturing and distributing trade in this territory. The factory is in actual operation, fabricating, assembling and marketing speakers throughout this territory. The name of the operating company is—Magnavox (Australia) Limited, and is under the managership of Mr. Don T. Hinchen, who has been associated with The Magnavox Company for many years in building up the loud speaker division of the radio industry in the Australian markets.

White Engineering Corporation, 32nd and Arch Sts., Philadelphia, Pa., appoints Walter H. Kelly sales director. Mr. Kelly is well known from his many years' association with the radio industry. He has represented Brunswick, Lyric, Crosley and Sonora, and is well recognized among the dealers and jobbers of the eastern seaboard. Mr. Kelly brings to the White Engineering Corporation, in addition to his radio experience, a long background of general sales experience.

Westinghouse General Catalog, 1931-1932, comprised of 1352 pages presenting descriptions and illustrations of apparatus representative of the myriad of products manufactured and sold by the Westinghouse Electric and Manufacturing Company, of East Pittsburgh, Pa., has been announced recently by that company.

The Newark Wire Cloth Company, 351 Verona Ave., Newark, N. J., manufacturers of wire cloth for all industrial purposes, announces that it is now manufacturing wire cloth of stainless steel. This cloth is made in all meshes, widths and lengths, and will be made as fine as 200x200 (40,000 openings per square inch) provided quantity orders will warrant.

Mr. Harry Kalker, sales manager of the International Resistance Company, manufacturers of Durham metallized resistors recently paid a visit to the Pacific Coast using Air-rail T-A-T route. Mr. Kalker visited his company's many accounts who are at present busy with the manufacture of mantel-type receivers. The International Resistance Company reports running close to peak production in order to fill the increased demand for metallized resistors.

REVIEW OF ELECTRONIC LITERATURE
HERE AND ABROAD

Electricity, ether and quanta

[F. PRUNIER] After having again derived Maxwell's equations as the most general equations of the movements of the ether, the author deduces certain properties of the ether. He then shows how these properties permit giving it certain electric, magnetic and gravitational characteristics. He is thus led to introduce into the theory of these phenomena some new types of waves and vibrations. These types of waves are precisely those which correspond to the famous Schrödinger equations. The author's conclusion is that wave-mechanics is not essentially different from the classical-mechanics, but that it can appear as a division of the latter just as in previous publications he has shown that the dynamics of relativity may be considered as a division of classical dynamics.—*Revue General d'Electricité, October, 1930.*

✦

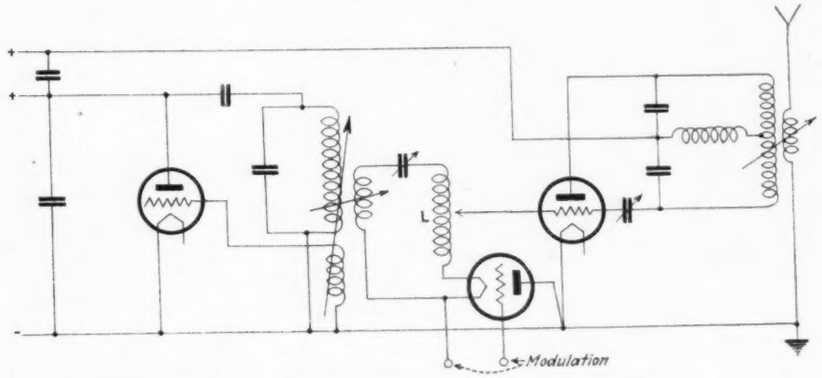
A simplified modulation circuit

[WEICHART AND LANGEWIESCHE] Communication from the Postal Department laboratories. With the grid modulation normal in German Broadcasting stations the insulation of the modulator tube filament supply is difficult and the capacity to ground troublesome. It is suggested that this can be overcome by using radio-frequency current for this filament and experiments have shown that results are entirely satisfactory. A further refinement is to obtain in a similar manner the necessary polarizing voltage for the modulator tube grid, by inserting in the same circuit the filament of a rectifier tube and feeding its plate with a radio-frequency voltage picked up by a coil coupled to the inductance L. (See circuit diagram below.)—*E.N.T., Berlin, October, 1930.*

✦

Electrical properties of soil at radio frequencies

[J. A. RATCLIFF AND F. W. G. WHITE] In the transmission of wireless waves over long distances the character of the earth may play a very prominent part. The effect of the earth has been determined from attenuation measurements and from measurements on the tilt of the wave front. The results are normally expressed in terms of the dielectric constant and the conductivity of the soil. The authors show that there is no sound basis for assuming *a priori* that these constants are independent of the frequency. By laboratory tests on samples of earth from two widely different locations and using two different methods of measurement, one a cathode-ray oscillographic method and the other a resonant method, they show that between one and ten million cycles the dielectric constant may show a four to one ratio, having smaller values at the high frequencies. The conductivity characteristic is a saddle-backed affair with a minimum at some intermediate frequency and showing only about a 25 per cent variation. The conclusion is reached that the only satisfactory way of measuring these quantities is to measure them for ground *in situ* and at the frequency required, either by the tilt method or by means of attenuation curves.—*Philosophical Magazine, October, 1930.*



Modulation circuit in which r.f. current is supplied to the filament to avoid ground capacity. Similarly a rectifier filament is fed with r.f. to supply grid voltages (Weichart and Langewiesche)

Triode generator and amplifier

[L. B. TURNER AND L. A. MEACHAM] It is common usage to state that the ideal efficiency of a linear oscillator or amplifier is 50 per cent. This, however, presumes that it is possible for the plate voltage to drop to zero and also that no grid current flows. By confining the swing of plate potential to the linear portion of the lumped characteristic and so adjusting coupling and voltages that the grid potential never becomes positive these authors show, both theoretically and experimentally, that the maximum output is obtained when the load resistance is twice the plate resistance and that the maximum efficiency, obtained for very large values of load resistance and small outputs, is 25 per cent. In the experimental work the harmonics are measured in the plate current by means of a calibrated amplifier; if these harmonics are translated into terms of plate potential it is shown that the most prominent harmonic (the 2nd) was less than one thousandth of the fundamental.—*Cambridge Philosophical Society, October, 1930.*

✦

Three-tube local receiver with the new "flat" tubes

[UNSIGNED] Of interest as being the first published description of a receiver developed independently of the tube-manufacturers (in this case in the "Funk" laboratory) using the new capacity controlled "grid-less" tubes (see page 346, October, *Electronics*). Points specially mentioned are the existence of somewhat more hum than with the normal indirectly heated tube, and the extreme critical nature of the regeneration setting.—*Funk, Berlin, November 7, 1930.*

✦

The differential condenser loudspeaker

[SCHWANDT.] Details of the new Vogt loudspeaker in which the membrane is negatively polarized and rests between two positively polarized (1,000 volts) gratings, the secondary of the input transformer being connected to these two latter. Curves are given and the claim of tenfold sensitivity as compared with the dynamic loudspeaker is made.—*Radio B.F.f.A., Stuttgart, October, 1930.*

On the theory of filter amplifiers

[S. BUTTERWORTH.] Technical literature is replete with solutions of the Campbell type of wave filter, consisting of recurrent similar sections. Here we have the analysis of a new type of filter in which each section is separated from the next by a thermionic tube. In other words, the problems of amplification and selection are combined as in the simple radio receiver.

Starting with a simple series-resonant circuit to be used in a low-pass filter the author shows that the voltage across the condenser is equal to the input voltage multiplied by the factor $\frac{1}{\sqrt{1+X^4}}$ where X is the ratio of operating frequency to cutoff (resonant) frequency, provided the constants of the circuit are properly related. Generalizing this relation he shows that $F=(1+X^m)^{-\frac{1}{2}}$ where $F=E_{out}/E_{in}$ and m is a factor which increases with the number of sections used in the filter. The conditions which must be satisfied in the cases of one or two element filters are stated. From this simple theory the article expands to include (a) multi-stage filter amplifiers, (b) band-pass filters, (c) band-stop filters and (d) high-pass filters. For each class a design table is included which shows the values of the constants to employ in the filter when using any given tube.—*Experimental Wireless, October, 1930.*

✦

Measurement of small currents

[Bh. S. V. RAGHAVA RAO AND H. E. WATSON] Increasing use of photo-electric cells has made the measurement of small currents a matter of prime importance. The circuit normally used for measuring small currents from a photo-electric cell or other source is one in which the cell and its attendant battery are arranged so as to charge the grid of a thermionic tube either positively or negatively and the resulting change in plate current is measured on a galvanometer balanced with respect to the initial plate current. Experiments showed that different types of tubes show widely different sensitivities. Even the very high vacuum tubes show some reverse grid current or "back lash" and this current is of extreme importance in these measurements. When the cathode (or anode) of the photo-electric cell is connected directly to the grid of the thermionic tube the grid current is equal to the photo-electric current. The change in plate current then depends on the variation from "free-grid" potential (i.e., $i_g=o$) to the potential which permits this current to pass and the mutual conductance of the tube. Since the back-lash is partially due to leakage caused by the anode voltage it is desirable to reduce the latter provided the mutual conductance is not decreased more by this same change.

The conclusions arrived at are: The main requirements in a valve to give high magnification of small direct currents are: extremely good insulating of the grid (a conducing factor being low filament temperature) high mutual conductance and low impedance and anode voltages much lower than normal. (See *Electronics, September, p. 290*).—*Experimental Wireless, October, 1930.*

✦

Some interesting television problems

[NOACK] Brief discussions of recent developments: Kirschstein's experiments showing that gas-filled photo-cells are not independent of frequency when high polarizing voltages are applied; Okolicsanyi's experiments tending towards greater clearness of image; the Zworykin system using the Braun tube—it is stated that this system has not come up to expectations and seems to be making little progress; the colored television systems of Aronheim (twelve colored rotating filters) and of Andersén (three such filters); synchronization problems in general and Korn's suggestion of a central radio station emitting nothing but a synchronizing frequency for the whole continent.—*Radio B. F. f. A., Leipzig, November, 1930.*

General new tendencies in loud-speaker construction

[NESPER] A general survey of recent German products—more especially the Isophon 4-pole, 4-watt; Pyreia 8-pole; Wufa Giant 60-pole; recent dynamic loud-speakers with permanent magnets; and the Vogt electrostatic in its latest form.—*Funk Magazin, Berlin, November, 1930.*

✦

The screen-grid tube as detector

[KAPLAN] Article specially for the short-wave telegraph amateur. Normal regenerative coupling is used but control of the regeneration is by variation of the screen-grid voltage, a variable series resistance of 50,000 ohms being inserted in this lead (with a large parallel condenser to reduce noise in operating). Claims of greatly increased sensitivity and easy operation (no change in frequency with change of regeneration) are made.—*Funk, Berlin, October 31, 1930.*

✦

Detection of ore-masses by radio

[VINOGRADOW] Simple description of a system using a small transmitter on 6,000 meters wave-length with a loop antenna capable of rotation about a vertical axis and a receiver with a loop antenna capable of rotation about both horizontal and vertical axes.—*Science et le Vie, Paris, November, 1930.*

✦ ✦ ✦

GERMANY'S "NBC"

The new radio center at Berlin was dedicated December 1. Broadcasting studios, a museum, research laboratories and the general offices of the commission are combined in one building in the German capital

Producing sinusoidal l.f. currents; their measurement

[J. G. Bedford and H. Josephs] Where a very wide range of output voltage and constancy of frequency are desirable, particularly at low frequencies, say from 5 to 100 cycles per second, thermionic valve methods of generation are at a disadvantage. The alternative solution adopted here is to provide a square topped wave with negligible transit time, filter this and measure the output frequency by means of a modified Maxwell's Commutator Bridge. The square topped wave is derived from a motor driven Baudot distributor; the filter consists of six 6-henry coils and a total of 40 mfd. capacitance. Oscillograms are included showing the wave form obtained at various frequencies.—*P.O.E.E. Journal, October, 1930*

✦

Logarithmic tube-characteristics

[Facal] It is suggested that the normal characteristic curves may with advantage be replaced by curves of Rp/Ep, "Durchgriff"$/Ep$ (or μ/Ep since the "Durchgriff" is 100 divided by μ), and mutual conductance$/Ep$, in which curves the values of Ep are plotted linearly but those of Rp, "Durchgriff" and mutual conductance logarithmically. It thus becomes possible, if the Ep scale is the same in all cases, to read complex characteristics such as the "Güte" (μ multiplied by mutual conductance) directly, and a permanent check on the correctness of the curves is given by the fact that the three ordinates for Rp, "Durchgriff" and mutual conductance respectively for any given value of Ep must total 1 (since the product of these three quantities is unity). Methods of obtaining the curves directly are given: or they can be calculated from the usual curves.—*Funk Magazin, Berlin, November, 1930.*

✦

The use of discharge tubes in electric circuits

[Richard Ruedy.] This paper discusses first the voltage-current curve of a typical glow discharge through gas at a low pressure. The greater part of the article then describes the many types of devices that have been developed to utilize the characteristics of this curve. These are discussed as follows:

1. The use of such tubes as voltage reducers, voltage regulators, and rectifiers.
2. Mathematical analysis of gas-incandescent cathode rectifiers.
3. The use of discharge tubes as relays.
4. Their use and analysis as glow tube buzzers in self-interrupting circuits.
5. The uses of gas-filled photoelectric tubes, particularly in the measure- of very small illuminations.
6. The discharge tube as a light source for neon lights and talking pictures.

A table is included which gives the characteristics of both the older and the more recent types of gas-filled photoelectric tubes. Dr. Ruedy in this paper has given a valuable summary of some of the many uses of glow discharge tubes.—*Journal of the Franklin Institute, November, 1930.*

✦

Amplifying tubes with photoelectric emission

[Von Ardenne] Such tubes, in which the cathodes emit electrons under the influence of light and not of heat as in the case of the normal tube, these electrons being attracted by an anode and the flow controlled by a grid in the usual way, can be used with high coupling resistances only (5 to 10 Megohms) on account of the high internal resistance. Audio frequency voltage amplifications of 10 to 30 per stage can thus be obtained.—*Z.f.Hf.T., Leipzig, October, 1930.*

✦

Compensated v.t. voltmeter with balanced bridge output

[W. G. Hayman] Due to its high input impedance the anode-bend type of rectifier is often preferred for use in measurements where the measured circuit must suffer a minimum disturbance. The question of the best output circuit to use brings up several interesting problems in regard to safety, sensitivity and stability. The author reviews the published literature in regard to this subject and then describes a "push-pull" or balanced bridge circuit in which one tube is used as a dummy to balance out the galvanometer current when the signal voltage is zero.—*Experimental Wireless, October, 1930.*

✦

New giant loud-speaker

[Neumann.] Details of the new type in which a very great increase of sensitivity has been attained, chiefly by the increase of the magnetic field to 20,000 gauss, this having been made possible by a new arrangement of the coils relative to the poles and by improved materials. Loads up to 800 watts can be handled and approximately 25% is radiated as sound energy, giving easily-understandable speech at 500 meters distance.—*Siemens Zeitschrift, Berlin, October, 1930.*

Modern receivers

[Lz] Continuation of the series of descriptions of modern German commercial products (see previous Digests). The Schaub, Owin and Pollux sets are described, with photographs and circuit diagrams. All are fully electrified, all have one screen-grid radio-frequency tube regenerative detector, and two resistance-capacity coupled audio-frequency stages. Prices range from $60 to $90 approximately.—*Radio B.F.f.A., Leipzig, November, 1930.*

✦

On the operation of externally-controlled tubes

[Von Ardenne.] Interesting measurements on the new flat Telefunken tubes with external "grid" (these Digests, previous months). In the case of the high-vacuum tube, the effective capacity between the active part of the external element and the space-charge on the glass within is of the order of 1 micromicrofarad, bridged by a resistance (the leakage-resistance of the glass) of about 10,000 megohms. The "gas" in the soft type of the tube is mercury vapor. Curves of the normal "grid volts—anode current" type (unobtainable in the normal manner) were got by the use of the oscillograph, and from these the amplification factor (of about 25) and plate resistance (about 400,000 ohms) were calculated. The actual voltage amplification with a coupling resistance of 1 to 3 megohms is about 20, and with 70,000 ohms about 15. Very little distortion occurred with "grid" voltages of 2, and practically none with 1 volt. The capacity between anode and cathode is of 3 to 4 micromicrofarads, between outer element and anode or cathode about 6 to 7 micromicrofarads. Microphonic effects are relatively small. Developments are suggested: firstly in the direction of increased amplification factor by a reduction in the size of the anode; and secondly by the use of a second grid around the anode or between anode and cathode (corresponding to the screen-grid tube).—*Funk, Berlin, October 3, 1930.*

✦

The multistage valve amplifier

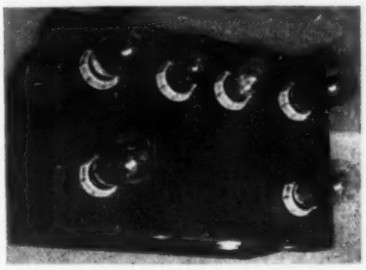
[A. C. Bartlett] The author considers the multistage amplifier from the point of view of recurrent networks as commonly applied to transmission lines. The effective voltage in the plate circuit of the tube is replaced by a constant current generator $G_m V_1$, where G_m is the mutual conductance and V_1 the input voltage. The ratio of output voltage to input voltage, and similar ratios, are obtained in terms of the hyperbolic functions of the circuit parameters.—*Philosophical Magazine, October, 1930.*

+ NEW PRODUCTS

THE MANUFACTURERS OFFER

Amplifier unit for table or rack mounting

AN AMPLIFIER DESIGNED for operation from 110 volt 60 cycle a.c. has been brought out by Ferranti, Inc., 130 West 42nd St., New York City. The unit shown, model 250 D-3 Amplifier, is arranged for table use. It can also be furnished for 245 tubes and for rack mounting. This amplifier has a gain of 70 db. and the manufacturers claim a uniform response within 2½ db. from 20 to 8,000 cycles. The principal



characteristics of this unit are: three stages of transformer coupling; an output of 10 watts; low operating temperature; dry type transformers and chokes with electrolytic condensers, eliminating breakdowns; input and output impedances as desired; and low hum level. Freedom from distortion and pleasing reproduction over a wide range for voice and music is claimed.—*Electronics, December, 1930.*

✦

Dynamic automobile speaker

DESIGNED ESPECIALLY FOR operating with automobile radio sets, is the Junior Model 510-B speaker, announced by the Utah Radio Products Company, 1737 South Michigan Ave., Chicago, Ill. It consists of a No. 510 six-volt battery type dynamic unit, built into an oxidized brass frame mounted in an octagon shape box 8½" wide and 4½" thick. The front metal grille is silk lined, making the speaker dust-proof. The octagon shape and compact size permits installation in a very limited space. It is supplied with convenient mounting brackets and a 5-foot cord. Operating current required, one ampere. List price, $12.

The Carter Radio Company, which is a division of Utah Radio Products Company, at the same address, has recently announced a 1931 catalog covering radio components, copy of which may be obtained by writing to the company direct. — *Electronics, December, 1930.*

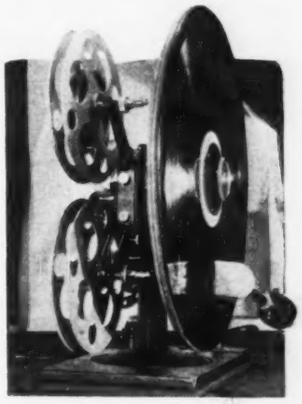
A 110-volt vacuum tube

DESIGNED TO OPERATE from the 110-volt lighting circuit, either direct or alternating current, a tube developed by the Lestein Corporation of America, 26 W. 17th St., New York City, has been announced. This tube is of the heater type and because of the excellent filament emission has a very high mutual conductance. Contrasted with a 112-type of tube, which it is designed to replace, the "Lestron" 110-volt tube has a mutual conductance of over 2,000 micromhos compared to 1,600 for the 112-type under the same conditions, i.e., 135 volts on the plate and 9 on the grid. The manufacturers expect a life of 3,000 hours, the tungsten filament operating at the comparatively low temperature of 1400° C. — *Electronics, December, 1930.*

✦

16 mm. sound movie equipment

FOR HOME, BUSINESS OR SCHOOL use, a new type of 16 mm. sound equipment has been announced by Victor Animatograph Corporation, Davenport, Iowa. This unit consists of the newly designed



Victor Model-5 Projector and No. 33 "Animatophone," assembled in one unit in which the turntable becomes an intimate part of the projector mechanism to insure perfect synchromism. A new feature of the "Animatophone" is the vertical mounting of the record instead of the usual horizontal mounting. Two models of amplifier speakers are offered for use with the "Animatophone." Amplifiers and speakers are compactly assembled in a carrying case, the No. 245 being about the size of the projector case and the No. 250 about half again larger.—*Electronics, December, 1930.*

D.C. circuit tester.

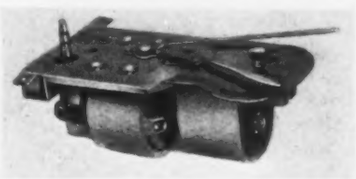
COMBINED IN ONE UNIT, a compact, portable instrument, accurate within 2 per cent, is the Model 563 d.c. circuit tester announced by the Weston Electrical Instrument Corporation, Newark, N. J. It consists of a Weston Model 301 meter, 3½ inch diameter having two resistance ranges — 5,000 and 50,000 ohms — mounted in a black Bakelite case. It contains a toggle switch for

range selection; a self-contained 1.5 volt flashlight cell; a leather strap carrying handle and a pair of 30-inch leads with test prods. This unit is particularly useful for checking resistance values and continuity of circuits during the process of manufacture and for service and installation work on many types of electrical apparatus such as: Telephone apparatus and circuits, radio transmitting and receiving sets, small electric motors, transformers, etc. List price, $21. — *Electronics, December, 1930.*

✦

Phonograph turntable motor

MODEL "G" TURNTABLE MOTOR, as brought out by the L. S. Gordon Company, 1800 Montrose Ave., Chicago, Ill., is equipped with Spanish felt gears to



assure silence in operation. It is also equipped with automatic stop control. This equipment can be installed easily and the manufacturers claim a quick starting torque and long life. List price, $30.—*Electronics, December, 1930.*

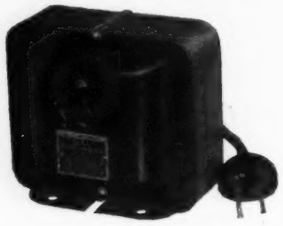
Lead-in-weld for tubes

THE AMERICAN ELECTRO METAL CORPORATION, 65 Madison Ave., New York City is introducing a new "Elmet" product a lead-in-weld for use in radio tube and incandescent lamps. An addition to their plant in Lewiston, Maine, has just been completed, where the newest type machinery for the manufacture of these welds has been installed. These welds are claimed to be of the highest obtainable quality. The American Electro Metal Corporation is prepared to serve the trade with these welds in the same efficient manner as with their well-established moly wire.—*Electronics, December, 1930.*

✦

Voltage compensator

A VOLTAGE COMPENSATOR which delivers regulated voltage to a.c. radio receivers and many other applications of vacuum tubes and relays, has been announced by the Sola Corporation, 2525 Clybourn Ave., Chicago, Ill. This compensator is designed to maintain the incoming line voltage within narrow limits and



it is claimed to lengthen the life of vacuum tubes, because of operation of the voltages within safety limits; protection of condensers from early breakdown, and elimination of trouble from the power compact. This unit has the following characteristics: capacity, 100 watts; input—95 to 135 volts—output 0.90 amperes at 110 volts. It is designed for operation on 60 cycles a.c. only, and weighs 7¼ lbs. This unit is also applicable to furnishing regulated voltage for film printing lamps, synchronous sound equipment, relay applications, and signalling devices. List price, $8.—*Electronics, December, 1930.*

✦

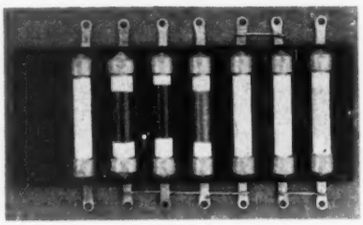
Photo-electric cell bulletin

AN INTERESTING BULLETIN describing the various types of photo-electric cells manufactured by the National Carbon Company, 30 East 42nd St., New York City, has been issued by this company. This bulletin gives a brief description of the types of vacuum and gas cells, and characteristic curves of the Eveready Raytheon Type Fotocells. It also gives an analysis of the photo-electric cell as a circuit element and suggestions regarding proper operation, when using these cells. Typical photo-electric cell circuits are shown to enable one to use these cells in different applications. —*Electronics, December, 1930.*

✦

Gang type metallized resistors

WHERE COMPACTNESS and simplicity are prime requisites, the gang type metallized resistor unit is particularly applicable. The International Resistance Company, 2006 Chestnut St., Philadelphia, Pa., has designed a new unit for small console or "mantelpiece" receivers. The unit comprises the necessary num-

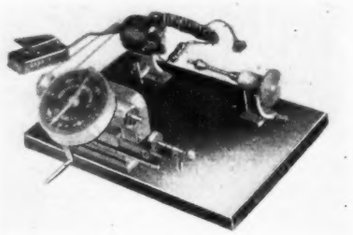


ber and values of standardized metallized resistors mounted on a strip by means of lead tips passing through holes in the strip and crimped on soldering lugs on the reverse side, making for ready wiring. The resistors may be supplied in practically any resistance value and in a wide range of current-handling capacities to meet the requirements of all types of receivers.—*Electronics, December, 1930.*

✦

Transformer winding machine

A SPACE WINDING MACHINE, designed primarily for winding radio frequency transformers, has recently been developed by the Meissner Manufacturing Company, 522 South Clinton St., Chicago, Ill. In the Model 30 machine, the turns of wire are accurately spaced by the spacing arm producing a uniform distributed capacity practically eliminat-



ing difficulty in matching. Various sizes of wire ranging from No. 20 to 38 inclusive can be wound and accurately spaced on this machine. The transverse mechanism, operating in any direction can be set to any desired length up to approximately six inches. The revolution counter combined with this mechanism permits operation at high speed and counts accurately from one to 10,000 turns. — *Electronics, December, 1930.*

Automatic record changing unit

AN INTERESTING AUTOMATIC record changing unit, has been announced by the White Research Laboratories, Inc., 33rd and Arch Sts., Philadelphia, Pa. The standard production models will be made in a Queen Anne wall table for the jobbing trade and will contain the automatic record unit, without an amplifier, equipped to be plugged into the regular radio set. There will also be a portable unit for installation in sound equipment, and a standard chassis for the radio manufacturer to install in

combination sets. On this unit the records are stacked in a pile on the turntable. It will hold up to 12 records of all makes. Ten and twelve inch records can be mixed in the pile and handled automatically by this machine. Means are provided to prevent records from slipping under the tone arm thus insuring good reproduction.— *Electronics, December, 1930.*

✦

Screen-grid tube for midget sets

A SCREEN-GRID TUBE designed especially for midget sets, to provide as much voltage gain as possible, has been announced by the DeForest Radio Company, Passaic, N. J. It is reported that this new type of tube has been checked in a number of midget sets and it has been found that the sensitivity of the average midget set can be doubled by using the new type tubes. For example, if a set has a sensitivity of 20 microvolts per meter, with the usual screen-grid tubes, the sensitivity may be increased to 10 microvolts per meter with the new type tubes. Although the new type tubes were essentially designed for use in midget sets, they are interchangeable with the standard-24 tubes and can be re-employed in any of the present-day radio sets for the purpose of doubling the sensitivity. The DeForest Company is prepared to supply the new type screen-grid tube, known as 424 High Gain Audion, at the same price as the standard product. —*Electronics, December, 1930.*

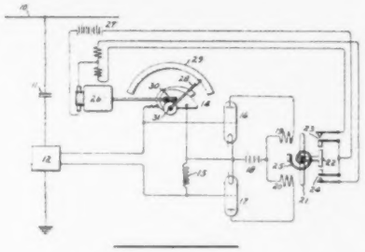
PATENTS

IN THE FIELD OF ELECTRONICS

A list of patents (up to Dec. 9) granted by the United States Patent Office, chosen by the editors of *Electronics* for their interest to workers in the fields of the radio, visio, audio and industrial applications of the vacuum tube

Electronics Applications

Frequency meter. Across a device whose frequency characteristic is to change, is a coil and condenser in series. Across each of these reactances is the input to a vacuum tube in whose plate circuit is the winding of a differential relay. When either the capacity or the inductance of the device changes, the differential relay operates to bring the circuit back to normal. An indicator on the variable reactance indicates what change has occurred in the circuit. W. Brückel and R. Schimpf, Berlin, Germany, assigned to G. E. Company. No. 1,780,669.



Railway control. Control of a block-system railway circuit by means of a vacuum tube and corresponding relays. P. E. Clark and James Clark, assigned to Continuous Train Control Corp., Detroit. No. 1,780,416.

Telephone conversation recorder. A method of connecting phonographic apparatus to a telephone line, so that communications can be recorded. M. H. Holland, assigned to Bell Telephone Laboratories, Inc. No. 1,780,919.

Test for magnetized objects. A vacuum tube method of locating faults in the structure of a magnetized object. Helmut Chappuzeau and Otto Emersleben, Kiel, Germany, assigned to Neufeldt & Kuhnke. No. 1,782,462.

Direct-current railway control. An electronic tube makes and breaks the feed current, opening automatic circuit device on a direct current railway. Ulrich Kloss, Berlin, Germany. No. 1,782,537.

Electronic tone producer. A tube with several grids has attached to each grid circuit a tuned circuit. In the plate circuit of the tube is an inductance, so that several frequencies can be generated. Frank E. Miller of New York, N. Y. No. 1,782,542.

Telephone recorder. A core and winding in magnetic and inductive relation to the core and winding of a telephone receiver picks up the sound current, after which they are amplified by electronic means and impressed on a record. M. J. Johnson, assigned to Dictaphone Corporation. No. 1,782,619.

Viscosimeter. A tube in which the liquid flows has wound about it inductances to the grid and plate circuit of two vacuum tubes. Variations in viscosity are indicated by the device. E. M. Symmes, assigned to Hercules Powder Co., Wilmington, Del. No. 1,780,952.

Explosion recorder. Apparatus using vacuum tubes to record the time of arrival of mechanical vibrations, involves translating these vibrations into electrical impulses, combining them with other impulses of higher frequencies, and recording the resultant combination. Frank Rieber, San Francisco, Calif. No. 1,780,567.

Frequency regulating system. An oscillation generator has coupled to it a constant frequency heterodyne which produces a beat frequency. This beat frequency is rectified and is used to maintain a constant relationship between the heterodyne frequency and the generator frequency. Henri Chireix, Paris, France. No. 1,782,807.

Sound receiver. A method in which the dielectric constant varies with certain vapors which in turn are varied by sound waves. A. B. Peterson, Fredericksburg, Denmark. No. 1,783,138.

Sound reproducing apparatus. Transformer connects a loud speaker to a vacuum tube amplifier. A second loud speaker is connected to the amplifier between the amplifier and the mentioned transformer. A. T. Bradshaw and M. J. DeForest, assigned to United Research Corporation, Long Island City, N. Y. No. 1,780,899.

Railway traffic control. An a.c. current is put on the track of a railway. Coupled to the tracks is a vacuum tube circuit so that the current flowing in one track neutralizes the current of the vacuum tube device induced from the other track. E. W. Bauman, assigned to Union Switch & Signal Co. No. 1,780,737.

Electrical testing system. Determining the relative values of two waves by comparing one with the magnitude of a given wave, and comparing the other with a given wave having a magnitude bearing a known relation to the first wave. A null method is used. Edmond Bruce, assigned to Bell Telephone Laboratories, Inc. No. 1,781,363.

Communication

Telegraph signal receiver. Stray frequency currents and dot frequency currents are filtered out from the incoming signal current. The remainder of the incoming signal is combined with a locally-generated signal of dot frequency and predetermined shape, whose frequency depends upon the dot frequency of the incoming signal. August Jipp, Berlin, assigned to Siemens & Halske. No. 1,782,524.

Radio amplifier. Tuned radio-frequency amplifier in which the effective input impedance of each coupling transformer at resonance is so adjusted that the ultimate amplification of all stages is substantially constant. W. A. MacDonald, assigned to Hazeltine Corp. No. 1,781,759.

Radio receiver. A method of trapping an induced charge upon one of the electrodes of an electron device. Oscillations to be detected and amplified are conveyed through the electrode having this induced charge. M. J. Rittenhouse and O. V. Maurer, Cleveland, Ohio. No. 1,781,861.

Radio-frequency amplifier. An amplifier known to radio engineers as the "Loftin White Circuit" in which the response of the amplifier can be pre-determined and adjusted to any desired characteristics whether flat over a frequency range or otherwise. F. W. White, assigned to RCA. No. 1,780,611.

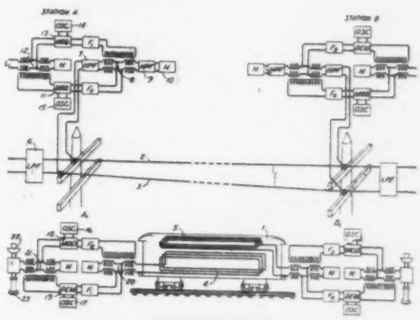
Current regenerative radio circuit. Tuned radio frequency stage in which an impedance is in series with the low potential end of the input tuned circuit and the filament of the tube. Octavius Knight, Westfield, N. J. No. 1,782,993.

Carrier current communication. A system of communication whereby stations on different lines, although operating at different frequencies, can be interconnected. F. W. Frink, assigned to G. E. Company. No. 1,783,037.

Radio-frequency amplifier. Combination of an antenna and a loop to the input of a radio frequency amplifier. H. H. Snow and W. T. Loughlin, assigned to Radio Frequency Laboratories, Inc. No. 1,780,987.

Radio transmitter. A means of coupling one oscillator to another by radiation from an antenna system. W. M. Brower, assigned to Federal Telegraph Co. No. 1,780,167.

Train communication system. A system of communicating by modulated high frequency signals between a mobile body and a fixed station, and a method of changing the transfer efficiency between the transmitter and the moving body, to provide a substantially constant transmission equivalent. J. W. Horton, assigned to Bell Telephone Laboratories, Inc. No. 1,780,921.



Signal control system. Two oscillatory circuits tuned to different frequencies. G. W. Cattell, assigned to Federal Telegraph Co. No. 1,779,585.

Untuned radio system. An untuned detection circuit and means whereby the effect of variable tuning is obtained by positively-controlled generation. L. W. Chubb, assigned to Westinghouse E. & M. Co. No. 1,781,268.

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TUBES and CONTROL

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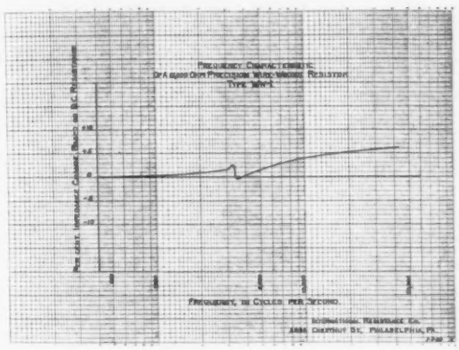

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Electronic Apparatus

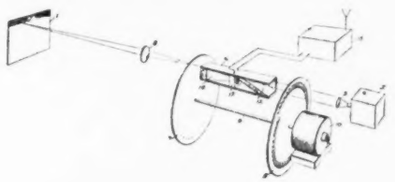
Oscillograph. A cathode ray oscillograph. Otto Ackerman, assigned to Westinghouse E. & M. Co. No. 1,779,794.

Rectifier. A full wave rectifier of the type having a large anode surface and small cathode surfaces. Jacques Risler, Paris, assigned to Risler Corp. of America, Kansas City, Mo. No. 1,780,504.

Vacuum tube. Apparently a tube in which the grid is replaced by a coil of wire wound on magnetic material. E. E. Blackman, assigned to Cleveland Redfield, Ogden, Utah. No. 1,780,698.

Television

A television transmitting system, including a Kerr cell, etc. E. F. W. Alexanderson and Ray D. Kell, assigned to G. E. Co. No. 1,783,031.

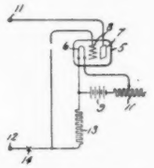


Generation, Detection, Etc.

Oscillation generator. A Piezo-electric device capable of vibrating simultaneously in several modes at different frequencies. E. I. Green, assigned to A. T. & T. Co. No. 1,780,229.

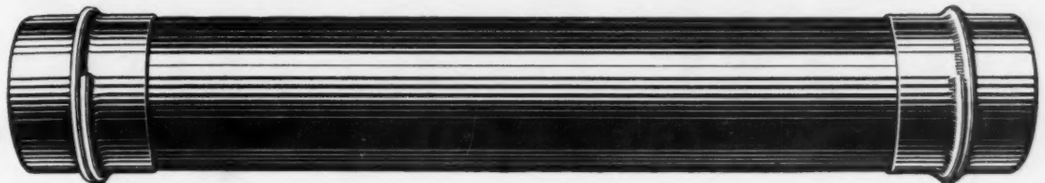
Double-wave rectifier. A system employing two vacuum tubes for rectifying a.c. C. B. Bartley and V. H. Dake, Pittsburgh, Pa. No. 1,782,228.

Linear detector. A resistance is inserted in the cathode lead to which the grid is attached, so that the volt-ampere rectifier characteristic of the device is substantially rectilinear. G. E. Spitzer, assigned to G. E. Company. No. 1,783,059.



Piezo oscillator. A means for manually adjusting the air gap between one conductive plate and the surface of the piezo crystals, as well as a means for indicating the distance between them. Russell F. Ohl, assigned to A. T. & T. Co. No. 1,783,130.

Piezo crystal device. Method of indicating intensity of high frequency oscillations by reflecting light upon mirror near piezo crystal. Vibrations of quartz cause movements of mirror when the light is reflected upon a screen. Alexander Meissner, assigned to Gesellschaft für Drahtlose Telegraphie, Berlin, Germany. No. 1,783,297.



With Leads

Bradleyunit Resistors

Solid Molded for Permanence

Research, more than a quarter century of painstaking costly research, is behind Bradleyunit Resistors.

Years of practical experience in meeting the demands of radio set manufacturers have led to the development of these solid molded resistors, famous for their permanence and accuracy. A huge plant with exceptional facilities for volume production turns out Bradleyunit Solid Molded Resistors by the millions.

These are the factors that produce uniformity in the quality and performance of Bradleyunit Resistors. Get an Allen-Bradley quotation on your next order.

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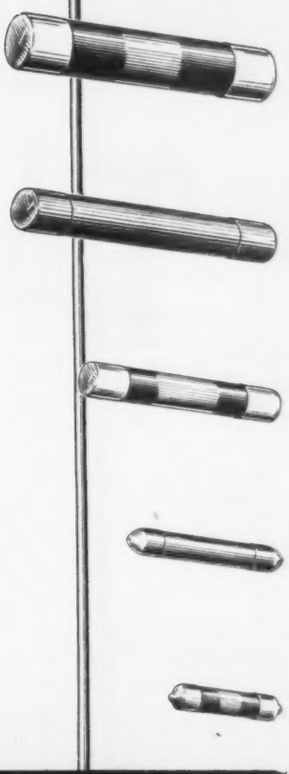
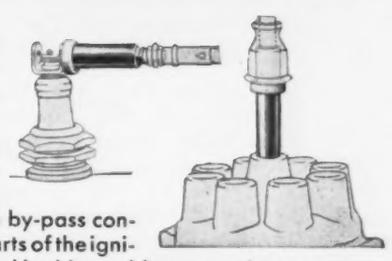
Without Leads



Bradleyometer

This remarkable "stepped" potentiometer has astounded radio engineers who were skeptical of its advertised performance. They have tried the new Bradleyometer and now know that no other type of potentiometer can rival it in flexibility and adaptability to every electronic unit. Any type of resistance-rotation curve can be arranged to meet your requirements. Samples will be sent to established manufacturers of electronic apparatus for test and trial.

Bradley Suppressors



These fixed resistance units, known as Bradley Suppressors, are doing astonishing things for motor car radio. By using them with suitable by-pass condensers in other parts of the ignition circuit, shielded ignition cables are no longer necessary. For simplicity, reliability and low cost, these units are in a class by themselves. Heat, moisture and age have no effect upon them. They are the last word for motor car radio.

ALLEN-BRADLEY RESISTORS

Produced by the makers of Allen-Bradley Control Apparatus

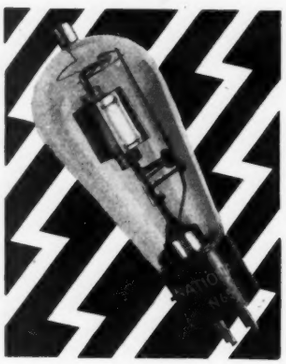
COST PER TUBE IS LOWER WITH TANTALUM

National Radio Tube Company

"WE find with the use of Tantalum," writes the General Manager of National Radio Tube Company, "that our cost per tube is lower even though Tantalum costs more than some other materials.

"This material reduction in cost is due to the fact that Tantalum is such an efficient 'getter', and serves to enhance the quality of our product to such an extent that our loss in gassy tubes is negligible.

"Also, we are thankful for your Tantalum Alloy spring wire which has already repaid us a thousand times by insuring us against flabby filaments.



Our engineers recommend the use of Tantalum in all tubes where extremely high vacuum is essential to long life and perfect service."

The findings of this company are backed up by those of other producers, both here and abroad, who are turning more and more to Tantalum to solve technical difficulties, improve quality and lower costs.

When you try Tantalum, you'll be surprised at the ease with which it can be stamped, formed, welded and cleaned. It's available in rod, sheet, and wire. May we send you a sample?

Fansteel is your best source of supply also for pure Molybdenum, hardened Molybdenum alloys, photo-cell metals and salts. Ample stocks for immediate delivery. Information and prices on request.

BIG NEWS NEXT MONTH

Watch these pages for announcement of importance to the vacuum tube industry

FANSTEEL PRODUCTS COMPANY, INC.

NORTH CHICAGO, ILLINOIS

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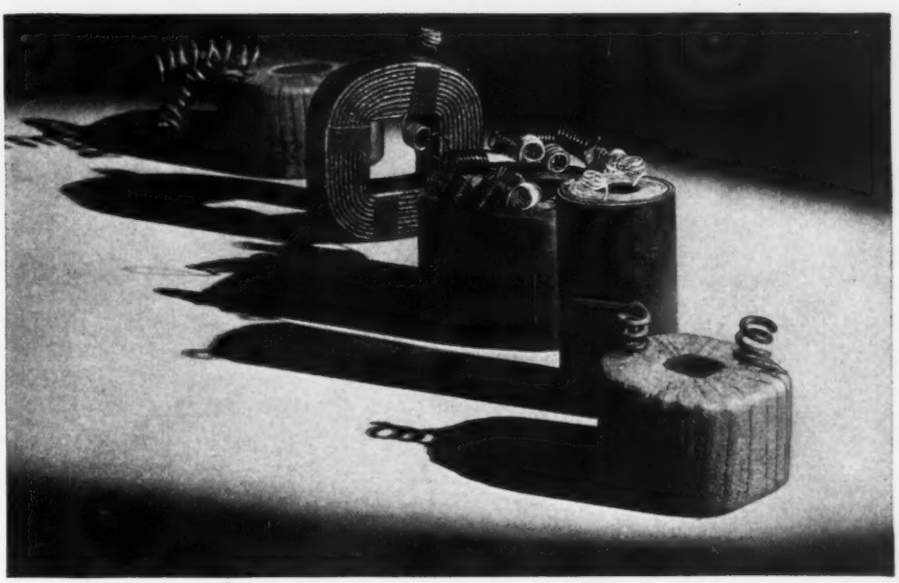
Every coil must be

ENGINEERED

for its specific job



The responsibility placed upon the coil windings used in electrical apparatus merits, in their design, the attention of the best engineering talent available.

Particularly in the design and manufacture of coils, the practical experience of General Cable engineers has enabled them to overcome difficulties that seemed insurmountable.

Because each coil must be specifically engineered for a given result, General Cable devotes much of its energy to research which uncovers new materials, new knowledge—often new fundamentals—that mean better coils.

To make certain that the coils you use are as efficient as possible, a review of their characteristics by our engineers may prove profitable.

GENERAL CABLE CORPORATION

EXECUTIVE OFFICES: 420 LEXINGTON AVENUE, NEW YORK • OFFICES IN PRINCIPAL CITIES

TYPE R. P. M. UNIVERSAL PANEL

Type R.P. and R.P.M. panels combine the various requirements of laboratories, universities and other institutions for the distribution of radio speech and music. They are complete and self-contained, easy to install and operate and reliable in service.

FERRANTI
AMPLIFYING EQUIPMENT

NEW DESIGN

The Type D rack amplifying equipment has been specially designed to give pleasing results by the faithful reproduction of both voice and music. It is suitable for all purposes where heavy duty amplification is required.

FAILURES ELIMINATED

Failures in the past have been caused largely by overheating resulting in the melting of compound contained in units in the power section. Overheating also often hastens the breakdown of compound filled condensers.

The Type D amplifier has no compound in its power section to cause trouble. Further, by liberal design and thorough ventilation, the temperature rise within the amplifier case has been reduced to less than 25 degrees centrigrade.

Electrolytic condensers of the Mershon type, compensated to have the same voltage drop, insure absence of condenser troubles.

Each unit has its own fuse so that it may be thoroughly protected. The result is continuous operation without failure of parts.

UNIT ASSEMBLY

The equipment has all been designed on the unit assembly principle so that and desired combination may be purchasey from stock units. Further, any desired additions may be made without disturbing the existing equipment.

INTERCHANGEABILITY

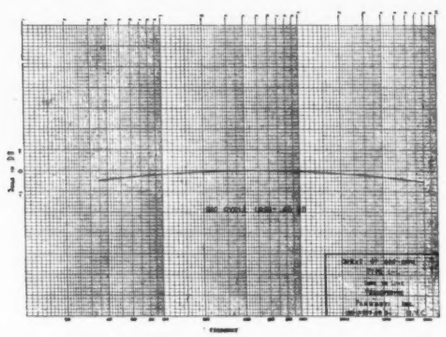
All amplifier units are quickly installed or changed. They have plug connections at both top and bottom so that they are instantly interchangeable without any change whatever in wiring.

INSTALLATION

As a result of this unit system of assembly and connection, practically all installation difficulties have been eliminated. It is only necessary to plug the units together and then insert plug connections for the speakers, the input, etc., or to connect by means of steel armored cables or conduits where required.

SPECIAL AUDIO and OUTPUT TRANSFORMERS

Now made in the U. S. A. on 48 hours' notice

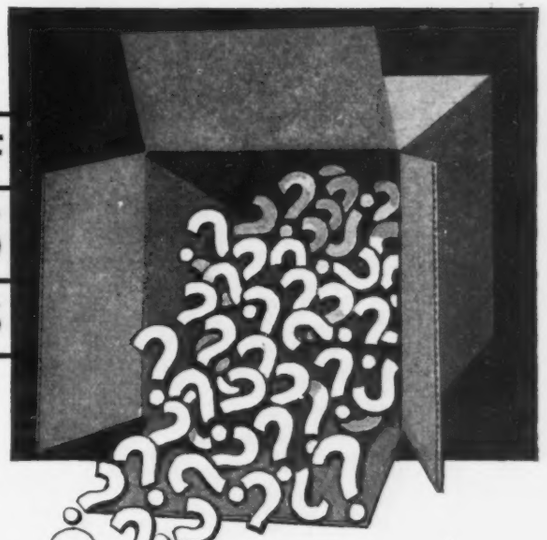


Curve of 600 Ohm Line to Line Transformers

Special audio and output transformers, made in the U. S. A., are now available for the exacting requirements of broadcast stations, public address systems, recording devices, laboratories, speech transmission and other uses where a flat curve over a wide frequency band is necessary. The curve shown above is typical of this newly developed series of transformers.

FERRANTI, INC., 130 W. 42nd St., New York, N. Y.

HAVE YOU ASKED YOURSELF THESE QUESTIONS ABOUT YOUR SHIPPING BOXES



?

The eagle eye of management is scanning all costs closely today—and for next year. When shipping boxes are the subject—ask yourself these questions:

ARE OUR BOXES STRONG ENOUGH—YET NOT TOO COSTLY

H & D Package Engineers can tell you exactly what requirements and traffic regulations your shipping boxes must meet.

CAN THE DESIGN OF OUR BOXES BE IMPROVED . . . . . ?

H & D Package Engineers are equipped to design the box that exactly meets the requirements of your product —without the waste of a penny's worth of packing material or packing labor.

CAN WE REDUCE THE NUMBER OF BOX DESIGNS . . . . . ?

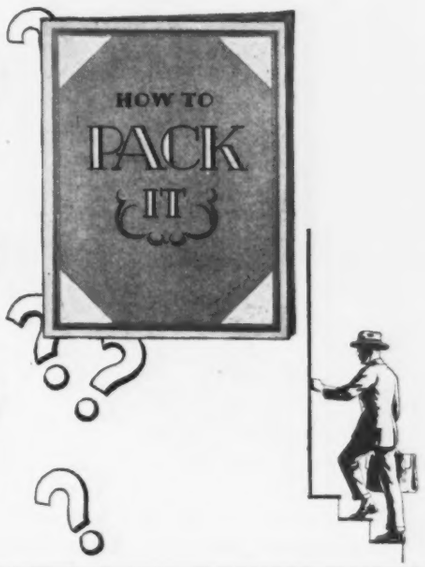
For many box users H & D Package Engineers have reduced the number of shipping box designs, thereby cutting box costs and increasing savings in storage space and packing labor.

ARE WE GETTING FULL ADVERTISING VALUE IN OUR BOXES ?

H & D Boxes can be printed in attractive colors with your trade mark, trade name or other designs that advertise your product in transit.

WHY NOT SEND FOR A COPY OF "HOW TO PACK IT" . . . ?

As a box user, these are some of the questions to which you should have the right answer. "How To Pack It," published by the H & D Package Engineers, will show you how packaging costs may be reduced with Engineered Packages. Mail the coupon below for a free copy.



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H&D

Many things to many different men . . . .

THROUGH the introduction of the electronic tube, robots of one kind and another now perform a thousand different activities. They stop elevators exactly level with the floor in skyscrapers. They see through fog—guiding aviators and locomotive engineers on their courses.

Electronic tubes are of two kinds. Alcoa Aluminum plays its part in the utilization of both. The "electric eye," or photo-electric cell, will respond instantly to the slightest change in the intensity of light. The "thermionic tube" acts as an amplifier; a detector—to detect infinitesimal quantities of electricity—or as an oscillation generator.

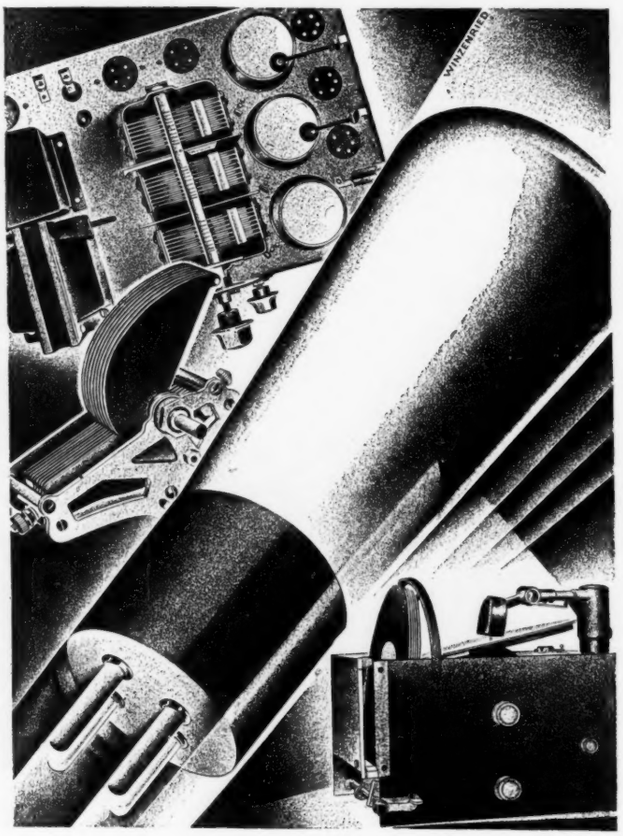
The coming of the many ingenious automatons employing the electronic tube is due to the far seeing work of a few scientists. Great credit should be given these pioneers in electronics.

To supply these scientists, and others, with proper materials, the research and development engineers of Aluminum Company of America have produced a whole family of light strong Alloys of Alcoa Aluminum that possess unique physical properties. What these strong Alloys of Alcoa Aluminum have done in the field of metals is of much importance. These alloys have shown beyond doubt that, where lightness and strength are factors, one or another of their number may be employed. All of them weigh approximately ⅓ as much as iron or steel. Some of them, when heat treated, attain a tensile strength of 55,000 pounds per square inch minimum. All resist corrosion. Some conduct heat 5 times faster than iron or steel.

Possessing these unique physical characteristics, the strong Alloys of Alcoa Aluminum have been closely associated with the rapid development of radio in the home. And their use has also contributed materially to radio broadcasting as well as the infinite variety and use of electron energy made possible through the introduction of the electronic tube.

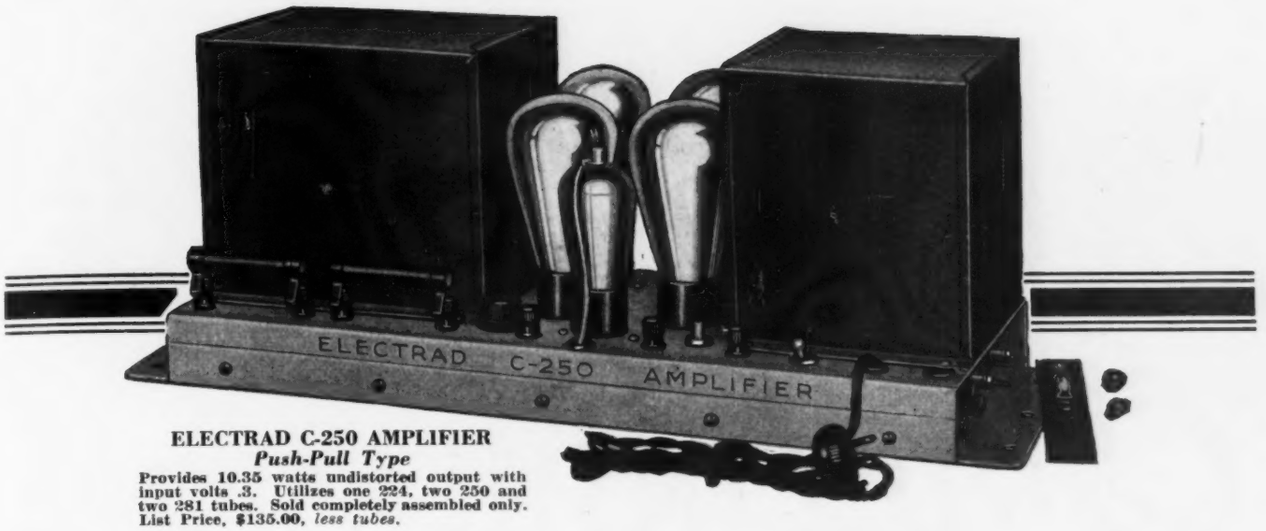
The very great part that Alcoa Aluminum has played in these advances is due to the fact that in addition to feather lightness and great strength, Alcoa Aluminum checks vibratory disturbance and hence eliminates microphonic and other resonance effects. You will find Alcoa Aluminum used in gang condensers, and aluminum is the only material that is used, commercially, for the electrodes of electrolytic condensers.

Builders of all types of equipment utilizing the electronic tube, or variations of its principle, need Alcoa Aluminum—use it. For a dependable source of supply they come to Aluminum Company of America. Quick delivery, absolute uniformity are assured. Your inquiries are solicited for Ingot; Sheet; Extruded Shapes; Rolled Shapes; Tubing; Forgings; Die, Sand, or Permanent Mold Castings; Stampings; Screw Machine Products; Draw Press Products; Wire; Bar; Rod. All are available in large or small quantities. Address ALUMINUM COMPANY *of* AMERICA; 2474 Oliver Building, PITTSBURGH, PENNSYLVANIA.



ALCOA

ALCOA ALUMINUM



ELECTRAD C-250 AMPLIFIER
Push-Pull Type
Provides 10.35 watts undistorted output with input volts .3. Utilizes one 224, two 250 and two 281 tubes. Sold completely assembled only. List Price, $135.00, *less tubes.*

High Quality Amplification

At Low Cost!

with the New ELECTRAD-LOFTIN-WHITE Direct-Coupled AMPLIFIERS

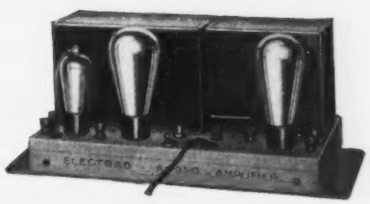
Engineers have long awaited the perfected advantages of the revolutionary Loftin-White *direct-coupled* system in an amplifier of high output and wide general adaptability.

The Electrad C-250 *Push-Pull* Amplifier is the answer. The C-250 *(illustrated above)* and its companions, the A-250 and the A-245, provide the notably high quality output, general stability, low initial cost and operating economies for which this system is noted.

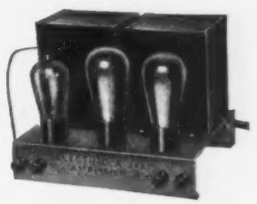
These Amplifiers are *perfected* products, of typical Electrad high quality and offer a range of power suitable for present-day needs.

They are readily adaptable to all usual requirements of sound amplification from microphones, phonograph pickups, radio tuners,—in fact, for all types of amplification of audio frequencies.

Our engineering department will be glad to show you how these Amplifiers can be used to your advantage. Write them, or mail coupon for descriptive literature.



ELECTRAD A-250 AMPLIFIER
Provides 4.6 watts undistorted output. Utilizes one 224, one 250 and one 281 tube. Sold completely assembled only. List Price, $87.50, *less tubes.*



ELECTRAD A-245 AMPLIFIER
Provides 1.6 watts undistorted output with one 224, one 245 and one 280 tube. Completely assembled or in kit form. List Prices, *less tubes:* Assembled, $40.00. Kit, $35.00.

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3. The power-factor remains constant between wide limits of temperature.
4. Sealed against moisture penetration, Isolantite panels retain their exceptionally high volume-resistivity under all climatic conditions encountered in service.
5. Isolantite products provide the required high and unchanging surface insulating qualities.
6. Facilities are available for the manufacture and quick delivery of any quantities of insulating parts, especially prepared for use in super heterodynes.

Isolantite Company of America, Inc.
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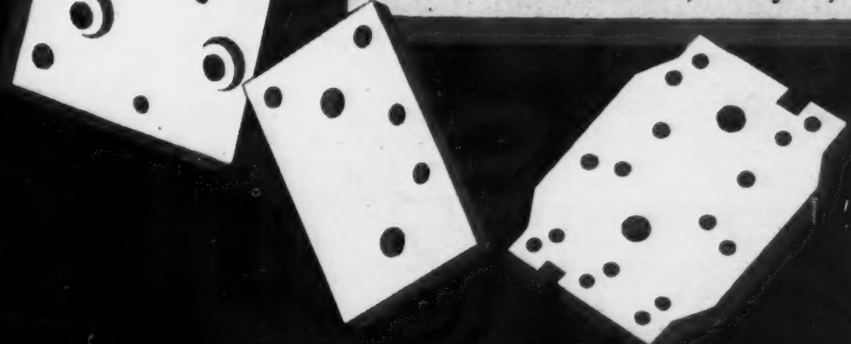


for

SUPERHETERODYNES

"We express our praise for the high standard of quality, dependable service and performance of CeCo Tubes."

F. H. WALTER, Prince-Walter Co., Lowell, Mass.

"For strenuous power equipment applications, CeCo's type 866 tube has achieved industry-wide recognition. It takes 7,500 volts peak and delivers .6 amps. load current with only 15 volts drop in the tube. Engineers describe the 866 tube as a veritable power house in itself ...especially suited for theater installations. May we send you full information?"

Ernest Kanter

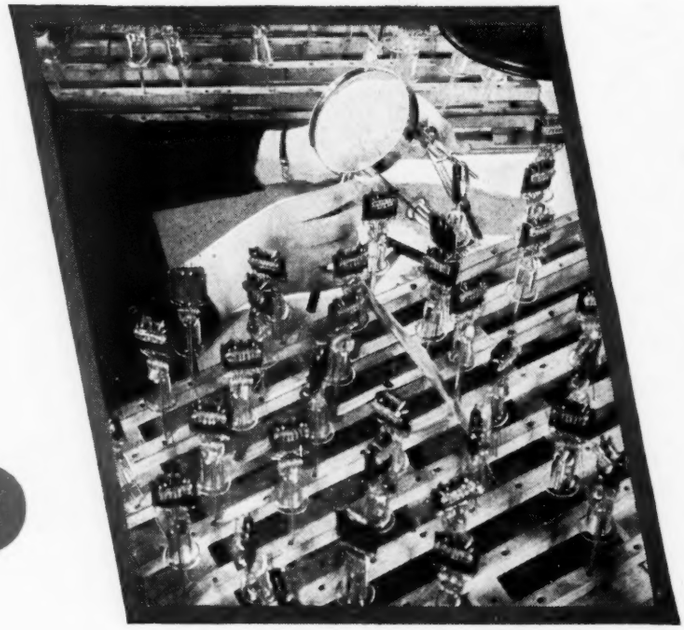
President,
CeCo Manufacturing Co., Inc.
Providence, R. I.

DO YOU KNOW?

1. The type 866 as well as all other power tubes are tested under actual operating conditions in CeCo's own station, WIXAC.

2. CeCo types 866, 250, 281, are used throughout the world in theater and power equipment applications.

3. CeCo Radio Tubes are licensed under the patents and applications of the Radio Corporation of America and affiliated companies.



An inspector checking stem assemblies . . . one of the 64 major inspections given each CeCo Radio Tube before final characteristics' tests are made. 42 engineers supervise these tests in a million dollar factory.

CeCo

Radio Tubes

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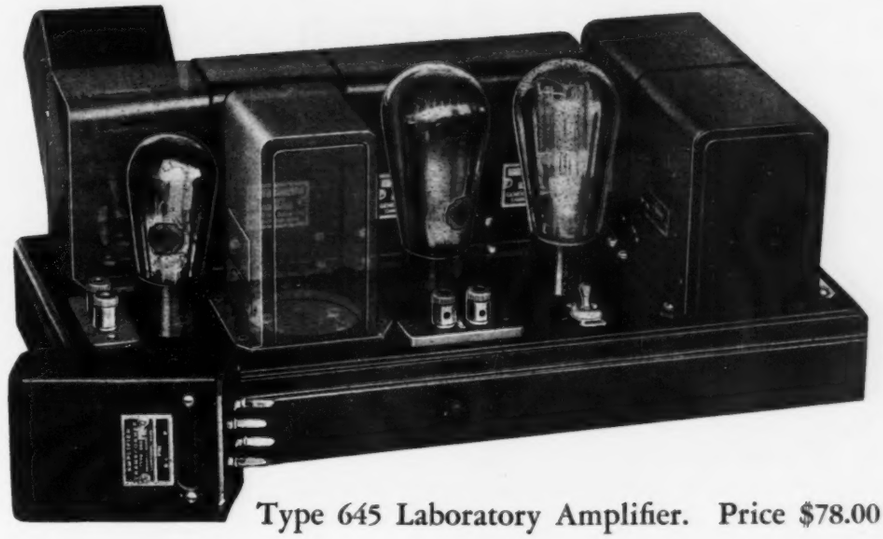
A MANY-PURPOSE AMPLIFIER



Type 645 Laboratory Amplifier. Price $78.00

DEVELOPMENT laboratories specializing in the applications of electron tubes need an amplifier in which any desired kind of coupling device may be inserted. The General Radio TYPE 645 Laboratory Amplifier shown in the accompanying illustration is an example of such a multi-purpose device.

This instrument is a complete alternating-current operated two-stage amplifier using a 226-type tube for the input and a 245-type tube for the output circuit. No coupling units are furnished, but in their stead are supplied two General Radio TYPE 274-HP Transformer Mounting Bases to which any desired kind of coupling unit may be connected. It is, therefore, possible to operate the amplifier with transformer coupling and shift on a moment's notice to resistance-capacitance coupling. The utility of this arrangement is obvious.

The TYPE 645 Laboratory Amplifier is not intended for public-address work. Its principal field of usefulness is in the laboratory where a flexible high-quality system is required. The power supply is carefully filtered and every precaution taken to minimize power-supply hum. The frequency range and the gain are primarily dependent upon the kind of coupling units installed.

If you are not receiving our monthly magazine, the General Radio *Experimenter*, a request on your business letterhead and a mention of your position will place your name on the mailing list.

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This photo-micrograph shows how perfectly "Sealedged" is made. Notice the construction of the edge.

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HAVE you considered the advantages of using "Sealedged" Nickel Wire Cloth for your special requirements? Here is a cloth, costing very little more than ordinary raw cut wire cloth . . . yet, it is made of the purest nickel obtainable . . . produced by special machinery of amazing precision . . . has even edges and an unusually smooth finish. One thing is certain, you will have no trouble from "Sealedged" wires dropping out. Let us send you a sample of this remarkable product.

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Branch Office: 66 Hamilton St., Cambridge, Mass.

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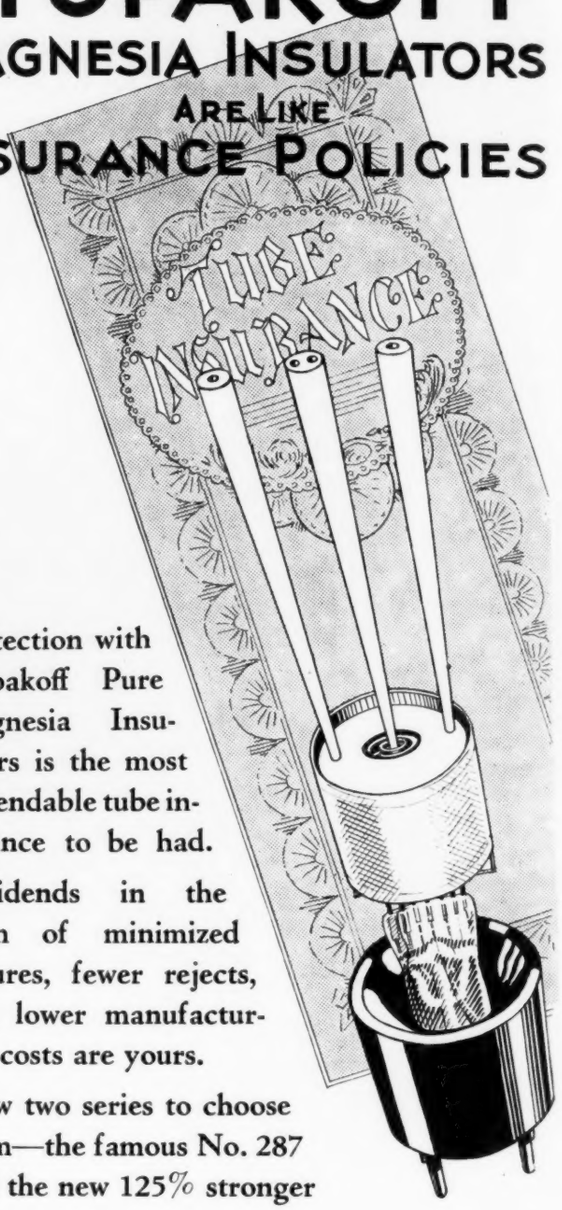

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Plate Volts	500.
Fil. Current Amp...	2.00
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This mercury vapor rectifier, run at the same filament voltage as a standard 280, will deliver ***three times as much rectified power!***

SET MANUFACTURERS, *think what this means* to you!

Greatly increased power for your electro dynamic speakers.

Higher and more efficient voltage for your tube layouts.

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The Lestron Tube is now available. With its filament adaptable to any voltage and frequency, the Lestron presents possibilities of extraordinary sales expansion to set manufacturers.

The Lestron requires no step-down filament transformer ....has higher mutual conductance than existing 5-volt filament types....higher emission....longer life.

The heater filament voltage can be varied to any commercial circuit—220-v., 110-v., 32-v., etc. The interchangeability of the tube with A.C. or D.C. is most desirable in metropolitan districts. The 32-v. type opens a way for set manufacturers to reach vast farm lighting circuit markets.

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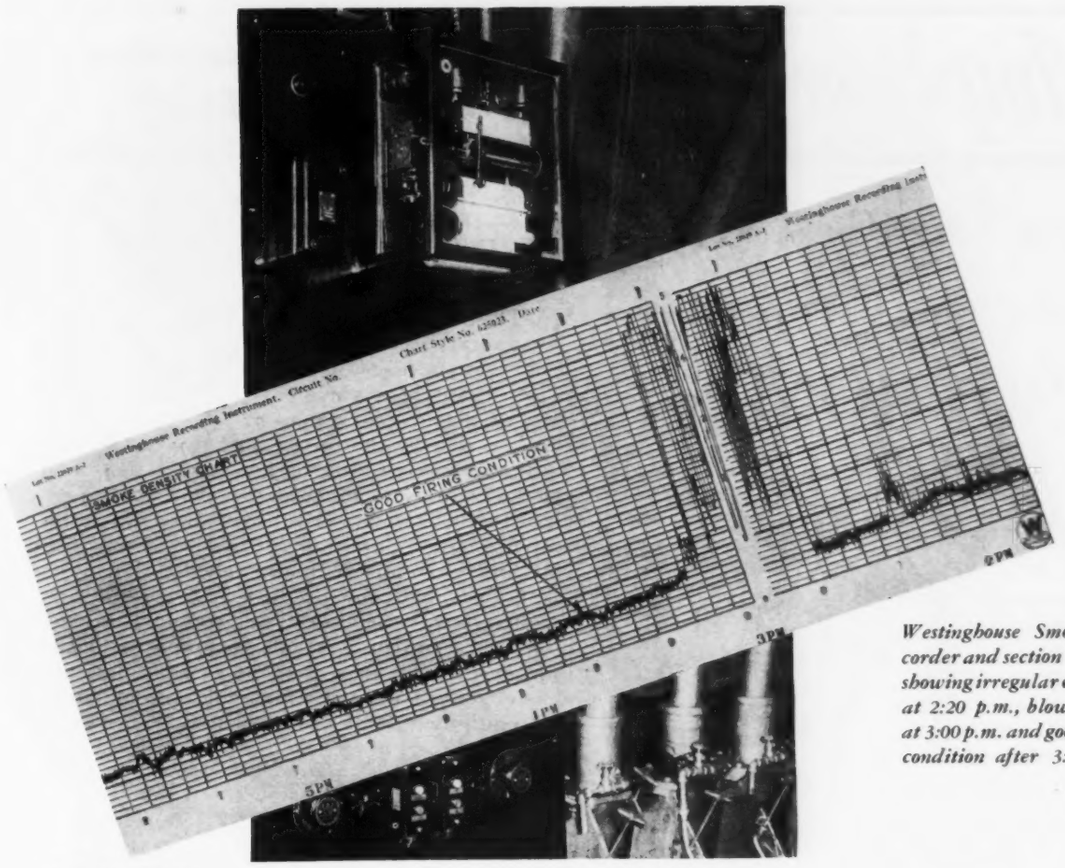

Westinghouse Smoke Recorder and section of chart showing irregular coal feed at 2:20 p.m., blowing soot at 3:00 p.m. and good firing condition after 3:15 p.m.

Tells
COMBUSTION CONDITIONS
at a glance

THE Photo-electric Smoke Indicator and Recorder tells the operator at a glance the conditions of combustion in the form of smoke density. And it also makes a continuous record of these conditions.

Past methods have depended upon the human eye—inaccurate because weather conditions vary, and altogether ineffective at night.

Here is a new, reliable and accurate instrument to promote increased combustion efficiency in every boiler room, with a reduction in the amount of smoke. Trial and test installations have proved its success.

For full information ask the Westinghouse district office near you for Leaflet 20413 entitled Photo-Electric Smoke Indicator and Recorder.

Service, prompt and efficient, by a coast-to-coast chain of well-equipped shops

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A New Series of Transverse Current MICROPHONES

Type CM	Type HM	Type JM
$65.00 less stand	$25.00 less stand	$25.00 less stand

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Write for 20-page catalogue and price list describing microphones, microphone amplifiers, 50-watt power amplifiers, giant dynamic air column units, exponential horns, synchronous and non-synchronous turntables, and complete panel mounted equipment for schools, hotels, hospitals, dancehalls, parks, football stadiums, baseball fields, polo grounds, skating rinks, golf links, steam-ships, clubs, restaurants, airplanes, airports, sound trucks, auditoriums, churches, theatres, etc.

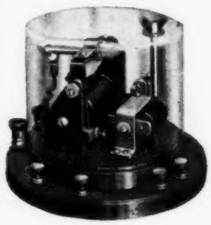
Amplion Corporation of America

133 W. 21st Street, New York City

A NEW Super-sensitive MERCURY RELAY

for use with Photo-Electric Cells

Breaks 10 Amps. at 110 Volts—Operates on Only 3.75 Milliamperes at 3 Volts.



THE Aminco Supersensitive Mercury Relay can be used in the plate circuit of a vacuum tube where the grid potential is varied by the use of a photo-electric cell. Thus the interrupting of a beam of light will cause the relay to make or break a 10 ampere circuit at 110 volts. Requires only 3.75 milliamperes for operation of the supersensitive coil and current for main relay coil can be taken from batteries or directly from the line through our rectifying transformer. May be used for a multiplicity of purposes including light responsive control of power. A diagram of connections with recommendations of auxiliary equipment will be furnished on request.

Write for free bulletin giving complete description

American Instrument Co., Inc.

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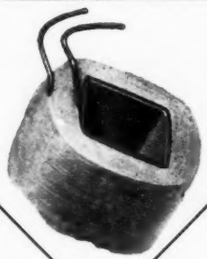

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as used by leaders in the electronic arts

Our clientele includes many of the foremost coil users—concerns whose products are internationally known for superior performance. These manufacturers come to us—and remain constant customers—because of our close cooperation and facilities for furnishing satisfactory coils.

We manufacture precision-built layer-wound coils up to No. 36 wire. Also automatically wound coils using finer sizes.

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Fine radio tubes result from perfection of many small parts

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Summerill tubing alone cannot make a fine tube, *but*, used in conjunction with other fine parts and careful workmanship, it will contribute much to the operating efficiency of the tube.

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Summerill tubing is chemically pure and mechanically accurate,—which means long life, constant characteristics and ease of assembly. Our facilities are such that we can readily handle your complete requirements to guaranteed schedules.

Make "Summerill" your nickel-tubing department.

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—anywhere—any time
—any quantity

The scientific care used in making Summerill Seamless Nickel Tubing is carried through until it reaches you. It is packed in a sturdy box carefully made to insure the contents against all shocks in transport. It assures perfect condition of the tubing when it reaches you.

The SUMMERILL TUBING COMPANY
FOUNDED 1899

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Factory—LEWISTON, MAINE

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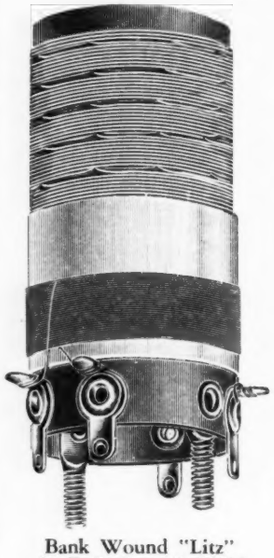

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Manufacturers of coils for 8 years.

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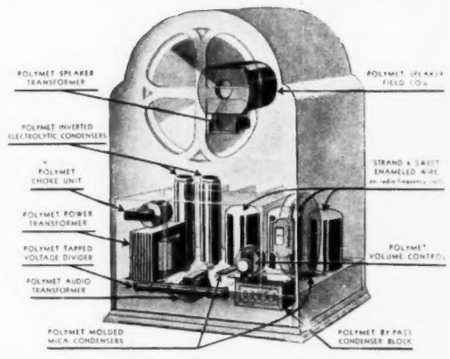

Always in the van—the trend toward the "midget" was foreseen in Polymet laboratories long before the demand for "midget" parts. Polymet engineers have produced unhurried, efficient, amply-tested essentials for wide-spread incorporation in these "pony" models. These parts measure up in every particular, except size, with standard Polymet Products—more cannot be said.

Polymet's prompt deliveries—from three large factories—help speed the production schedules of most leading receiver manufacturers.

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G-E pedestal-mounted, self-contained, a-c. photoelectric relay unit CR-7505-D1

G-E indoor-type light source CR-7500-A1 furnished either with or without separate transformer for supplying low voltage

G-E d-c. photoelectric relay unit CR-7505-B1

A PEDESTAL-MOUNTED photoelectric relay, entirely self-contained, and adjustable for the sensitive control of factory or office illumination; a new d-c. photoelectric relay—slightly larger, but in general appearance similar to the familiar CR-7505-A2 a-c. unit; a weatherproof, self-contained photoelectric relay; complete light sources for outdoor and indoor installations. These are the new and important additions to the line of photo-electric equipment manufactured by General Electric.

Each unit in this extended line is built with the same painstaking attention to detail that characterizes every piece of General Electric control equipment. Each unit is ready the day you receive it to go to work for you—to bring its practical magic into operation on your production line, in your office, or at scattered points about your factory.

You are invited to write to-day for complete information. And, if you will indicate your particular problem, G-E engineers will be glad to coöperate with you in its solution—photoelectrically.

G-E a-c. photoelectric relay unit CR-7505-C2, self-contained and designed for all-weather use out of doors

G-E outdoor light source CR-7500-B1 complete with self-contained transformer

301-62

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In fact, Kingston has for thirty years rendered a specialized mechanical and electrical manufacturing service to manufacturers which has simplified their production problems and reduced their production costs.

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Manufactured exclusively in our own plant for the Radio and Electronics Industries. Material fabricated to all recognized standards or your specifications.

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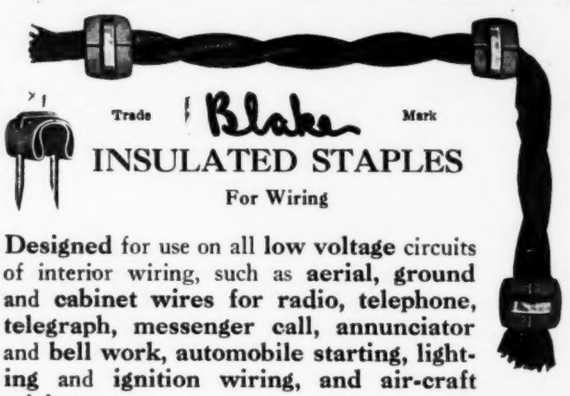

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For Wiring

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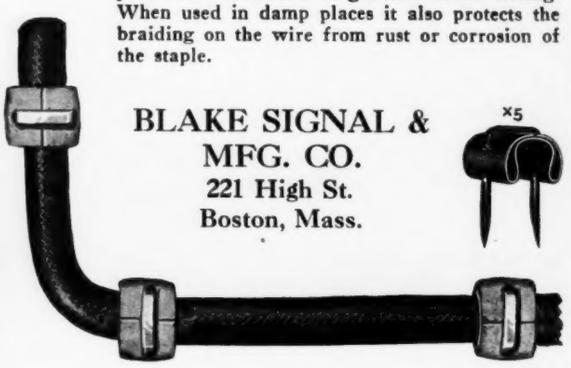
The insulation on these staples gives an added protection from leaks on grounds on the wiring. When used in damp places it also protects the braiding on the wire from rust or corrosion of the staple.



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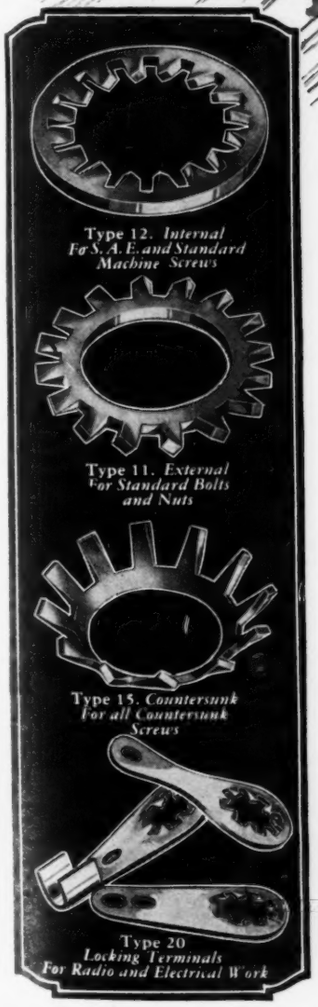

NO industry stands still—each year new products are brought forth—new features are incorporated in old models and new standards of performance and efficiency are reached. This is the result of constant striving for leadership and is the foundation of any manufacturing success.

The fact that thousands of manufacturers—those who are recognized as the most progressive in their industries—are now using Shakeproof Lock Washers on their products is proof that this positive locking method is contributing to industrial progress. The twisted steel teeth of Shakeproof bite into both the nut and work surface and only applied force can release their hold. This means absolutely tight connections that cannot shake loose and makes possible the new high standards of performance that so many industries have attained.

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Quantity — One

IF your resistor requirements are modest in quantity, and if you have been using home-made or other resistors because the question of cost deterred you from using the best, we would appreciate quoting on your requirements.

The pitchrod determines the accuracy of winding wire on tubes

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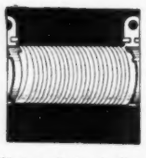
The tension of the wire must be correct

Lack of accuracy in pitch or tension will cause shorted turns or



If a perfect winding like this is to result

"Swimming" of wire after one coat of enamel is fused on

Control of these factors is perfect. Two wire sizes are often wound on one tube.

WARD LEONARD ELECTRIC CO.
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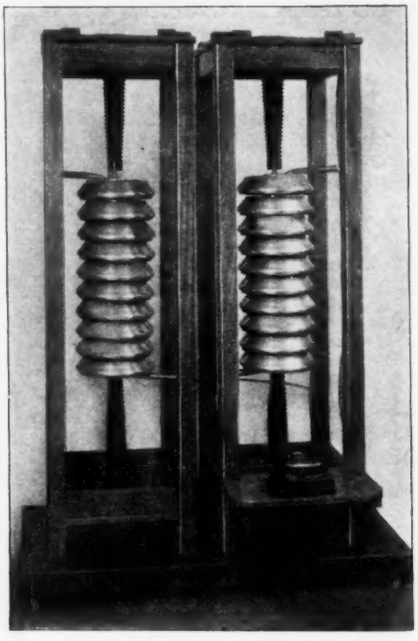
resistor specialists for more than 39 years

Taylor High Voltage RESISTORS



THE TAYLOR High Voltage Resistors provide the ideal arrangement for high-tension voltmeter multipliers to accurately determine constant, ripple or sinusoidal kenotron rectified voltages.

The illustration (above) shows a 150,000 volt installation employed at the Bureau of Standards, Washington, D. C., which does not draw enough current to interfere with the operation of X-Ray or kenotron tubes.

By the employment of proper auxiliary apparatus and correction charts an accuracy of 0.01% is obtained. This system of measuring high potentials is not affected by atmospheric conditions and eliminates the use of the spark gap, spectrographs, and primary voltage measurements.

As the resistors are carefully protected by corona cases it is possible to make measurements of potentials up to 300,000 volts or more.

Readings may be made by associate apparatus such as a D'Arsonval movement (milliammeter or high resistance voltmeter) or remotely by the use of a Leeds and Northrup recorder.

Write for our Bulletin 200-K

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Shallcross Mfg. Company
ELECTRICAL SPECIALTIES
700 PARKER AVENUE
Collingdale, Pa.
(NEAR PHILADELPHIA)
Accurate NON-INDUCTIVE WIRE WOUND RESISTORS

January

electronics

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Forecast and Trends Issue

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Forms close December 26

Ultra Sensitive
Semi-Suspended Meters

Suitable for experimental work with Photo Electric Cells

Currents as low as .003 Microampere can be measured. Suitable multipliers can be added to extend the range to any desired value, controlled by a well designed selector switch.

These meters can also be supplied in type 507 and type 505.

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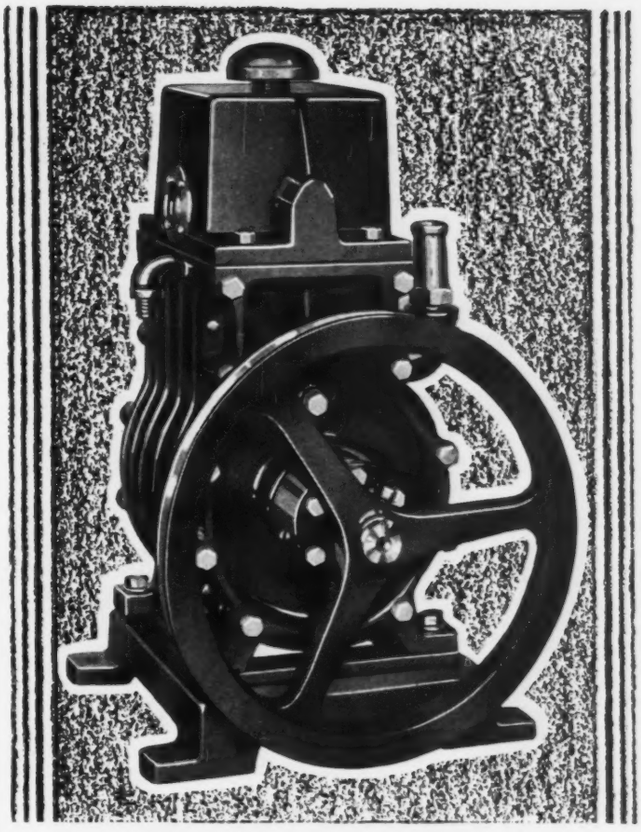

4 new principles introduced by the CENCO-HYPERVAC HIGH VACUUM PUMP

Instantaneous exhaustion of large volumes from atmospheric pressure to tenths of a micron mercury pressure is a new accomplishment for oil pumps originating with and introduced by the Cenco-Hypervac pump.

For the information of engineers, Hypervac high speed exhaust is a product of four new principles of vacuum engineering—the combination of a large volume piston roughing stage with a Cenco rotary finishing stage . . . complete vacuum sealing of finishing stage . . . adaptation of pump shell to air cooling by conduction and radiation to effect a lower running temperature . . . automatic pre-rectification of all oil which contacts the rotary finishing stage.

Wherever applied Cenco-Hypervac pumps are reducing time costs in production and improving products by delivering lower pressures.

For specifications and prices address the Central Scientific Company, 460 East Ohio Street, Chicago, Illinois.

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CENCO HIGH VACUUM PUMPS
Hyvac Megavac Super Cenco vac Rotovac Hypervac
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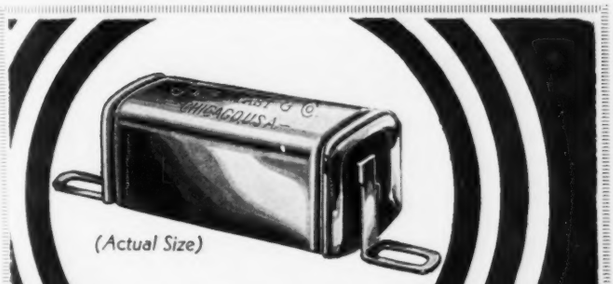

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The Outstanding
BY-PASS CONDENSER

Again Fast has anticipated the industry's needs . . . and offers this tiny by-pass condenser which conserves chassis space, assembling time, and first cost. Completely enclosed. Moisture proof . . . leak proof . . . trouble proof.

Quick deliveries on any quantity.

Samples and specifications on request.

FAST

Specialists in Radio Condensers
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Ellis—The Most Beautiful Microphone acclaimed the Best in Performance

Everybody who has seen Ellis Microphones has commented on the exceptional beauty of workmanship—AND everybody who has used the Ellis Microphone has acclaimed it of outstanding performance.

A complete line of two-button microphones for indoor and outdoor Public Address systems, Radio Broadcasting, and Home Recording, available in several models at $25.00, $45.00 and $75.00 list. Also a complete line of stands, cables, and other accessories. New two-button Hand-Mike now ready. Have you seen our new DEMOUNTABLE Microphone?

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A Photoelectric Cell

designed for industrial application

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STANDARD

MICA

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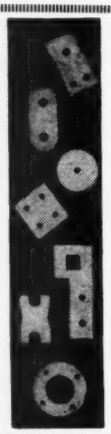

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Tar Heel Mica is used by many prominent concerns—its excellent quality making it especially suitable for even the most exacting requirements.

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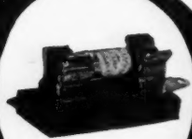

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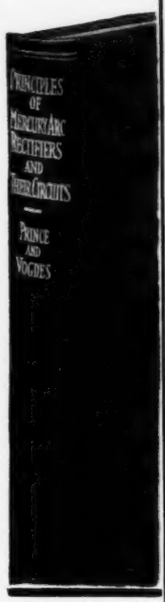

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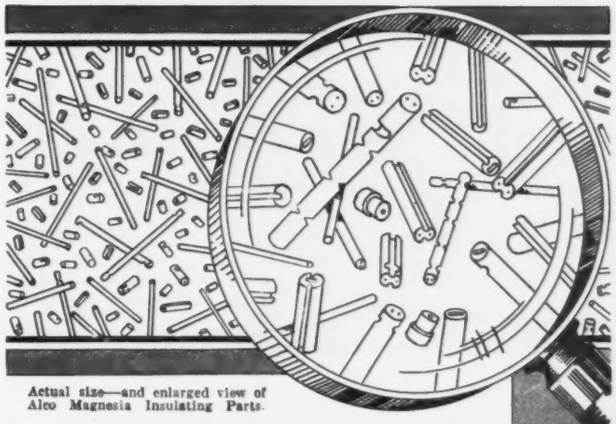

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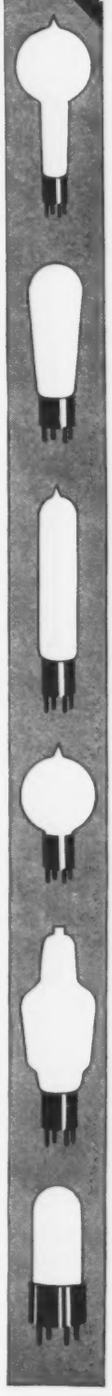

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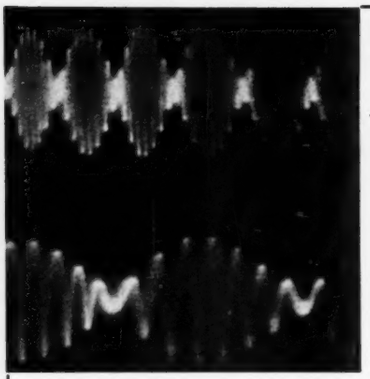

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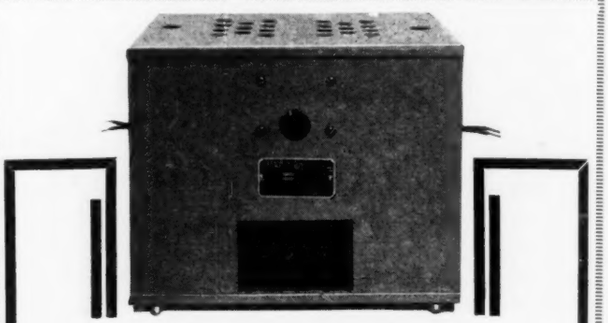

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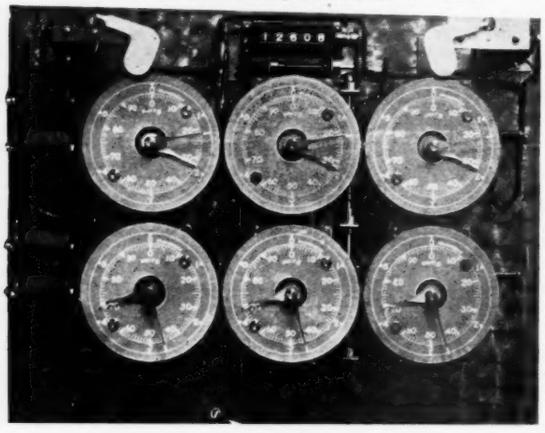

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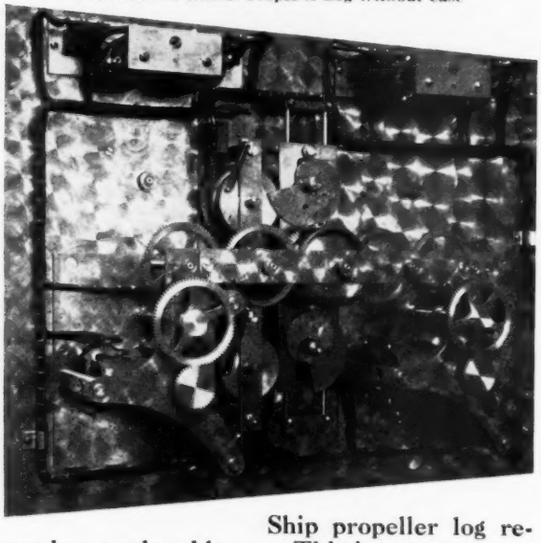

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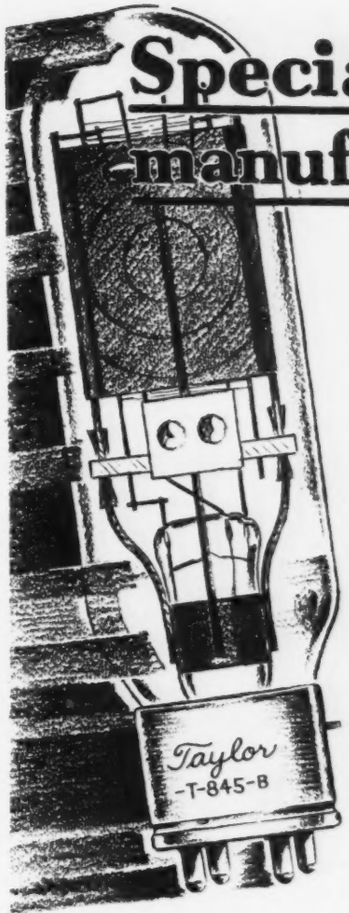

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